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Agronomic and seed traits of soybean lines with high-oleate concentration

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ABSTRACT

Soybean [*Glycine max* (L.) Merr.] oils with high-oleate (HO) or low linolenate (LL) concentrations have greater oxidative stability and longer shelf-life than conventional soybean oil. Soybean lines with the transgenic event DP-305423-1 produce a high-oleate oil and those with the *fan1*(C1640) and *fan3*(RG10) alleles produce a low-linolenate oil. The objective of this study was to evaluate the agronomic and seed traits of high-oleate/low-linolenate (HOLL) lines, high-oleate/normal-linolenate (HONL) lines, and normal-oleate/normal-linolenate (NONL) lines selected from four single-cross populations formed by crossing a HOLL parent homozygous for the transgene and the two *fan* alleles to four conventional NONL cultivars. A minimum of 14 $F_{3:5}$ lines of each class in the four populations were evaluated in five environments during 2009. The mean fatty ester concentration averaged across populations was 786 g kg^{-1} oleate and 24 g kg^{-1} linolenate for the HOLL class, 784 g kg^{-1} oleate and 56 g kg^{-1} linolenate for the HONL, and 226 g kg^{-1} oleate and 75 g kg^{-1} linolenate for the NONL. The mean yield of the NONL class was significantly greater than the HOLL by 4.5% and the HONL by 3.0%. Of the 10 highest yielding lines in each population, 60% were NONL, 25% HOLL, and 15% HONL. Although the mean yields and frequencies of high-yielding lines in the HOLL and HONL classes were less than the NONL class, it would be possible to select cultivars of both classes that yielded as well as NONL cultivars. For the other agronomic and seed traits, the maximum difference among the three classes in the four populations was 9 g kg^{-1} for protein concentration, 6 g kg^{-1} for oil concentration, 7 mg sd^{-1} for seed weight, 2 d for maturity, 4 cm for height, and 0.4 for lodging score. The overlap in the distributions of lines within the three classes for the agronomic and seed traits indicated that it would be possible to select HOLL and HONL cultivars comparable to NONL cultivars.

INTRODUCTION

Soybean [*Glycine max* (L.) Merr.] oil accounted for 37.54 million metric tons of the world's consumption of vegetable oil for 2007/2008 (United States Department of Agriculture, 2009). Despite its widespread use, conventional soybean oil lacks the oxidative stability required for some industrial and food applications due to its high concentration of linoleate (520 g kg^{-1}) and linolenate (80 g kg^{-1}) (Dutton et al., 1951; Okkerse et al., 1967; Fehr, 2007). The multiple double bonds in linoleate (18:2) and linolenate (18:3) are responsible for their lower oxidative stability than oleate (18:1) or the saturated fatty esters palmitate (16:0) or stearate (18:0) (Dutton, 1963; Okkerse et al., 1967).

The most common method of reducing the percentage of linoleate and linolenate in soybean oil has been chemical hydrogenation (Dutton, 1963; Okkerse et al., 1967). Through this process, the percentages of unsaturated fatty esters are reduced, resulting in a greater oxidative stability of the oil. An undesirable outcome of hydrogenation is alteration of the arrangement of hydrogen atoms on some of the double bonds from the *cis* to the *trans* configuration (McMurry, 2008). The resultant *trans* fatty esters have been associated with an increase in coronary heart disease (Willett and Stampfer, 1993; Weggemans et al., 2004). Conventional breeding and genetic engineering have been used to produce soybean oils with elevated oleate and reduced linoleate and linolenate concentrations that have adequate oxidative stability without hydrogenation (Fehr, 2007).

Recessive alleles at three major loci have been identified that lower linolenate concentration (Fehr, 2007). The two alleles involved in this study were *fan1*(C1640) and *fan3*(RG10). The *fan1*(C1640) allele developed by Wilcox et al. (1984) has a single nucleotide

polymorphism (G to A) in *GmFad3A* (Chappell and Bilyeu, 2006). The *fan3*(RG10) allele has a single nucleotide polymorphism (G to A) in *GmFad3B* (Reinprecht et al., 2009).

A high-oleate soybean was developed by insertion of a copy of the *Fad2-1* gene into soybean that was designated as event 260-05 by DuPont (Knowlton, 1999). Their high-oleate (HO) event resulted in a soybean oil with 64 g kg^{-1} palmitate, 33 g kg^{-1} stearate, 856 g kg^{-1} oleate, 16 g kg^{-1} linoleate, and 22 g kg^{-1} linolenate (Knowlton, 1999). Commercial use of the 260-05 event was limited because the *Fad2-1* gene was linked to the *bla* gene for ampicillin resistance as a selectable marker (United States Food and Drug Administration, 1996; Fehr, 2007). To overcome concerns about presence of the *bla* gene in soybean products consumed by humans, DuPont reinserted the *Fad2-1* gene into soybean using a herbicide resistance gene (*gm-hra*) as the selectable marker. Through the transformation process, an event designated DP-305423-1 was selected that increased oleate concentration (Kinney et al., 2008).

It is possible with the *fan1*(C1640) and *fan3*(RG10) alleles and the DP-305423-1 transgene to develop soybean cultivars that have high oleate with normal linolenate concentration (HONL) or high oleate with low linolenate (HOLL). The choice between the two types would depend on the functional properties of each oil and on the relative performance of the two types for agronomic and seed traits compared with conventional cultivars that have normal oleate and linolenate concentrations (NONL). Warner and Gupta (2005) studied the flavor and frying qualities of cottonseed oil (CSO), high-oleate soybean oil (HOSBO), low-linolenate soybean oil (LLSBO), and a 1:1 blend of HOSBO and LLSBO. The 1:1 blend of HOSBO (851 g kg^{-1} oleate) and LLSBO (20 g kg^{-1} linolenate) had less of a fishy flavor than HOSBO, and an improved oxidative stability compared with LLSBO. They suggested that the fishy flavor of the HOSBO oil may have been associated with its low concentration of linoleate

(13 g kg^{-1}) relative to its linolenate concentration (20 g kg^{-1}). They indicated that an increased concentration of linoleate may help to mask the undesirable fishy flavors produced by linolenate. Based on their research, a HOLL soybean oil that has high-oleate, moderate-linoleate and low-linolenate concentrations may be preferable to a HONL oil. No research has been reported in which the functional properties of the two oils have been compared.

Previous studies with soybean lines containing high-oleate transgenes have not shown any negative influence on seed yield or other agronomic and seed traits (Kinney, 1996; Graef et al., 2009). However, none of the previous research has examined the impact of combining a high-oleate transgene with recessive alleles for reduced linolenate to obtain a HOLL oil. The objective of our research was to compare the performance of HOLL, HONL, and NONL lines from four segregating populations for agronomic and seed traits. The study would provide necessary information on the feasibility of developing HOLL or HONL cultivars with the DP-305423-1 transgene that have comparable agronomic and seed traits to those of NONL cultivars.

LITERATURE REVIEW

Importance of *Trans*-fatty Acids

Trans-fatty acids have been found to be associated with coronary heart disease (CHD). Willett and Stampfer (1993) studied 85,095 women who had not previously been diagnosed with CHD, a stroke, diabetes, or high cholesterol. During eight years, there were 431 women diagnosed with new cases of CHD (324 non-fatal, 107 fatal). The mean *trans*-fatty acid intake in 1980 of the women included in the study was 4.0 g d^{-1}. Of the *trans*-fatty acid intake, 600 g kg^{-1} was from vegetable fats and 400 g kg^{-1} was from animal fats. The intake of *trans*-fatty acids and occurrence of CHD were significantly correlated at the 0.001 probability level. Weggemans et al. (2004) also found that an intake of more than 3 g d^{-1} of *trans*-fatty acids resulted in an increased risk of CHD.

Due to the association between *trans*-fatty acids and CHD, the United States Food and Drug Administration declared that all food and dietary supplements sold after January 1, 2006 must be labeled for their *trans*-fat content (United States Food and Drug Administration, 2003). This was done to allow consumers to make more informed decisions in food selection (United States Food and Drug Administration, 2003).

Influence of Reduced Linolenate and Elevated Oleate on Oxidative Stability and Flavor

Soybean oils with low linolenate have better flavor and frying qualities than conventional soybean oil. Warner and Gupta (2003) fried potato chips in a low-linolenate soybean oil (LLSBO) (224 g kg^{-1} oleate, 597 g kg^{-1} linoleate, 20 g kg^{-1} linolenate) and ultra low-linolenate soybean oil (ULLSBO) (248 g kg^{-1} oleate, 582 g kg^{-1} linoleate, 8 g kg^{-1} linolenate) for 25 h. and stored them for 1, 3, 5, and 7 weeks at 25 C. The LLSBO and ULLSBO were obtained from

Protein Technologies International, St. Louis, MO. They found that the chips fried in ULLSBO had better flavor and oxidative stability than the chips fried in LLSBO.

Su and White (2004a) evaluated the flavor stability of a high-oleate soybean oil (HOSBO)(790 g kg^{-1} oleate, 65 g kg^{-1} linoleate, 38 g kg^{-1} linolenate) alone and in various blends with conventional soybean oil (215 g kg^{-1} oleate, 548 g kg^{-1} linoleate, 80 g kg^{-1} linolenate). The 790 g kg^{-1} oil had 65 g kg^{-1} linoleate and 38 g kg^{-1} linolenate; the 650 g kg^{-1} oleate blend had 187 g kg^{-1} linoleate and 49 g kg^{-1} linolenate; the 510 g kg^{-1} oleate blend had 303 g kg^{-1} linoleate and 60 g kg^{-1} linolenate; the 370 g kg^{-1} oleate blend had 418 g kg^{-1} linoleate and 71 g kg^{-1} linolenate; and the conventional soybean oil had 215 g kg^{-1} oleate, 548 g kg^{-1} linoleate, and 80 g kg^{-1} linolenate. They also evaluated a LLSBO with 253 g kg^{-1} oleate, 582 g kg^{-1} linoleate, and 14 g kg^{-1} linolenate. The HOSBO, LLSBO, conventional, and three oil blends were used to fry bread cubes for 1 min. Half of the cubes were tested immediately after frying and half were stored and tested 3 d later. The fried bread cubes were evaluated for flavor characteristics by a trained taste panel and for volatile compounds. Their ranking from highest to lowest flavor quality and stability was the LLSBO, HOSBO, 650 g kg^{-1} oleate blend, 510 g kg^{-1} oleate blend, 370 g kg^{-1} oleate blend, and conventional soybean oil.

Su and White (2004b) used the same oils and bread cubes described above to study frying stability. The bread cubes were fried for 1 min. Half of the cubes were tested immediately and half were stored for 3 d before testing. Their ranking from highest to lowest for frying stability was the HOSBO, 650 g kg^{-1} oleate blend, LLSBO, 510 g kg^{-1} oleate blend, 370 g kg^{-1} oleate blend, and conventional soybean oil.

Warner and Gupta (2005) used potato chips to measure the flavor and frying qualities of high-oleate soybean oil (HOSBO) (Protein Technologies Intl., St. Louis, MO), LLSBO (Protein

Technologies Intl.), cottonseed oil (CSO) (Archer, Daniels, Midland Co., Decatur, IL), and a 1:1 blend of HOSBO and LLSBO. The HOSBO had 851 g kg^{-1} oleate, 13 g kg^{-1} linoleate, and 20 g kg^{-1} linolenate; LLSBO had 261 g kg^{-1} oleate, 554 g kg^{-1} linoleate, and 20 g kg^{-1} linolenate; CSO had 177 g kg^{-1} oleate, 522 g kg^{-1} linoleate, and 1 g kg^{-1} linolenate; and the blend had 555 g kg^{-1} oleate, 289 g kg^{-1} linoleate, and 20 g kg^{-1} linolenate. Fresh Idaho Russet potatoes were cut 1 mm thick and fried for 1, 5, 15, and 25 h, and aged for 1, 3, 5, and 7 wk at 25 C. The potatoes were analyzed for flavor characteristics by a trained 16-member panel, and the oils used for frying were analyzed per se for their frying quality and stability. They determined that potato chips fried in HOSBO had a greater fishy flavor and greater oxidative stability than LLSBO. The 1:1 blend had better flavor than HOSBO and greater oxidative stability than LLSBO. The CSO had a flavor similar to that of LLSBO and better than that of HOSBO. The CSO also had greater oxidative stability than the LLSBO. They suggested that the less desirable flavor of the HOSBO compared with the 1:1 blend may have been to do its lower concentration of linoleate (13 g kg^{-1}) than linolenate (20 g kg^{-1}). As a result, the concentration of desirable flavor components associated with the degradation of linoleate in the HOSBO during frying was not sufficient to mask the undesirable flavors produced by the breakdown of linolenate.

Warner and Fehr (2008) studied the frying characteristics of mid-oleate/ultra low-linolenate soybean oil (MO/ULLSBO) using tortilla chips. A MO/ULLSBO (521 g kg^{-1} oleate, 312 g kg^{-1} linoleate, 10 g kg^{-1} linolenate), ultra low-linolenate soybean oil (ULLSBO) (278 g kg^{-1} oleate, 549 g kg^{-1} linoleate, 11 g kg^{-1} linolenate), hydrogenated soybean oil (HSBO) (436 g kg^{-1} oleate, 155 g kg^{-1} linoleate, 7 g kg^{-1} linolenate), and a conventional soybean oil (SBO) (242 g kg^{-1} oleate, 527 g kg^{-1} linoleate, 71 g kg^{-1} linolenate), were used in the study. The ULLSBO and MO/ULLSBO were obtained from soybean lines developed by Iowa State University. The

soybean lines used to produce the ULLSBO had the *fan1*(A5*), fan2*(A23), and *fan3*(A26) alleles. Soybean lines with the mid-oleate trait contain the *ol* allele from M23. Frying of 50 g tortilla chip samples was conducted in 90 s intermittent batches every 20 min, for a total of 55 h. They measured total polar compounds to determine oxidative stability. The more quickly polar compounds formed, the lower the stability of the oil. They found that the MO/ULLSBO produced the same amounts of total polar compounds as HSBO after 55 h of frying and less than the ULLSBO or SBO. This indicated that increasing oleate and decreasing linolenate would be desirable for producing a stable oil.

The studies discussed above suggest that a soybean oil high in oleate would be desirable to increase the frying stability of soybean oil, while a low-linolenate soybean oil would be desirable for its flavor characteristics and increased oxidative stability compared to conventional soybean oil. A soybean oil with the combined benefits of both high-oleate and low-linolenate concentration would be a desirable product. A soybean oil with only increased oleate concentration would be desirable also, if its concentration of linoleate was greater than that of linolenate.

Industrial Applications

A soybean oil with high-oleate may have useful industrial applications. Soybean oils that have been hydrogenated are not desirable for biodiesel because they will solidify as heat is generated by friction causing undesirable wear of moving parts (Kinney, 1998). When HOSBO was compared to mineral oil lubricants in machine-wear lubrication tests, it performed similarly (Kinney, 1998). Kinney and Clemente (2005) reported that biodiesel blends are one of the

potential uses for soybean oil with high-oleate concentration due to its increased oxidative stability and lubricity properties in colder climates compared to conventional soybean oil.

Graef et al. (2009) compared HOSBO from the HO event 335-13 to standard soybean- and canola-derived biodiesels and grade No. 2 petroleum-based diesel. The study was performed on a John Deere 4045T engine, a John Deere 3150 tractor, and a 1994 Dodge Ram 2500 5.9 L Cummins truck. Emissions from the 335-13 HOSBO produced 4.7% less brake-specific nitrogen oxides (NO_x) compared to petroleum-based diesel. Transesterification of the 335-13 HOSBO also resulted in increased cold flow and energy content of the fuel compared to methyl esters from the 335-13 HOSBO. They concluded that use of a biodiesel from transesterified high-oleate/low-saturate soybean oil would effectively lower NO_x emissions. Combining a soybean oil with these characteristics and proper engine design would practically eliminate NO_x emissions.

Inheritance of High-Oleate Concentration

The 260-05 HO event was created by insertion of the DNA sequence for *GmFad2-1* into soybean embryos with the *bla* gene for ampicilin resistance that was used as a selectable marker (Knowlton, 1999). The 260-05 event was inserted in the cultivar A2396 (Asgrow® Seed Company, Dekalb, IL) by particle bombardment. *GmFad2-1* is the gene that controls the soybean's ability to convert oleate to linoleate. By inserting a copy of the *GmFad2-1* DNA sequence into the soybean genome, expression of the *Fad2-1* gene was suppressed (Kinney, 1996). The suppression of *Fad2-1* resulted in an increase of oleate concentration. Kinney (1996) reported that after observations of the $R_{0:1}$, $R_{1:2,}$ and $R_{2:3}$ generations, the high-oleate transgene segregated as a single-dominant allele. He analyzed the oleate concentration of the

homozygous plants and found that it ranged from 840 g kg^{-1} to 880 g kg^{-1} across the three generations. The 260-05 event produced oil with concentrations of 64 g kg^{-1} palmitate, 33 g kg^{-1} stearate, 856 g kg^{-1} oleate, 16 g kg^{-1} linoleate, and 22 g kg^{-1} linolenate (Knowlton, 1999). Commercial use of the 260-05 event was limited because the *Fad2-1* gene was linked to the *bla* gene for ampicillin resistance as a selectable marker (United States Food and Drug Administration, 1996; Fehr, 2007).

Buhr et al., (2002) inserted a DNA sequence for *GmFad2-1* and *GmFatB* into the soybean cultivar A3237 (Asgrow® Seed Company, Dekalb, IL) by transformation with *Agrobacterium tumefaciens*. *GmFad2-1* controls the conversion of oleate to linoleate, while *GmFatB* encodes a palmitoyl thioesterase, which decreases the concentration of palmitate. They identified the transgenic event as 335-13. The transgene segregated as a single-dominant allele. The β-glucuronidase (*GUS*) gene was used as the selectable marker. The 335-13 event produced oil with concentrations of 22 g kg^{-1} palmitate, 25 g kg^{-1} stearate, 911 g kg^{-1} oleate, 14 g kg^{-1} linoleate, and 21 g kg^{-1} linolenate. The 335-13 event is yet to be commercialized due to multiple companies owning intellectual property required to develop the event.

The construct used in the recent HO event DP-305423-1 differs from the 260-05 event primarily in that it does not contain the *bla* gene for ampicillin resistance as a selectable marker and uses a different seed-specific promoter. Instead, the DP-305423-1 event contains the *Gm-hra* gene, which codes for acetolactate synthase (ALS) herbicide resistance (Kinney et al., 2008). The construct was inserted by particle bombardment of the cultivar Jack (PI 540556). The DP-305423-1 event produced soybean oil with 63 g kg^{-1} palmitate, 44 g kg^{-1} stearate, 765 g kg^{-1} oleate, 36 g kg^{-1} linoleate, and 54 g kg^{-1} linolenate. The transgene segregated as a single-dominant allele.

Inheritance of Low Linolenate

The development of the three major genes for reduced linolenate concentration in soybean was summarized by Fehr (2007). The low-linolenate alleles involved in this study were *fan1*(C1640) (Wilcox et al., 1984) and *fan3*(RG10) (Stojsin et al., 1998). Wilcox et al. (1984) used ethyl methane sulfonate (EMS) to mutate the cultivar Century to lower the linolenate concentration. The mutant line C1640 produced from this mutagenesis event had a linolenate concentration of 34 g kg^{-1} compared to 70 g kg^{-1} for Century. Reduced linolenate in C6140 was controlled by a single recessive allele designated *fan1*. At the molecular level, Chappell and Bilyeu (2006) studied the molecular change in the *fan1* locus that resulted in the *fan1*(C1640) allele. The *fan1*(C1640) allele resulted from a point mutation in the *GmFad3A* gene (G to A).

Stojsin et al. (1998) used EMS to mutate seeds of C1640 to obtain the line RG10 that had 14 g kg^{-1} lower linolenate concentration than C1640. They determined that the genetic basis of reduced linolenate in RG10 was a result of an additional mutation in the *fan1* locus. The new mutation was not associated with any cytoplasmic effects. They designated the new allele for low-linolenate in RG10 as *fan-b*. The *fan-b* allele acted in an additive manner when combined with the *fan1*(C1640) allele. They reported that the *fan-b* allele in RG10 in the absence of the *fan1*(C1640) allele resulted in linolenate concentration of < 25g kg^{-1}. Their interpretation of the genetic basis of reduced linolenate in RG10 was found to be incorrect through molecular research by Reinprecht et al. (2009).

Reinprecht et al. (2009) determined that RG10 had the *fan1*(C1640*)* allele (*Fad3A)* from C1640 and a novel *fan3* allele (*Fad3B)* that resulted from mutagenesis of C1640. They indicated that the mutation in *Fad3A*[(*fan1*(C1640)] accounted for a 50% reduction in linolenate and the mutation in *Fad3B[fan3(RG10)]* caused an additional 30% reduction in linolenate. They

reported that both mutations were inherited independently in an additive manner. The *fan3*(RG10) allele resulted from a point mutation in the *GmFad3B* gene (G to A).

Agronomic Performance of Lines with Modified Oleate and Linolenate Concentration

Kinney (1996) reported that HO transgenic soybean lines in the $R_{4:5}$ through $R_{7:8}$ generations produced stable oleate concentrations across generations, environments and years. The mean oleate concentration of the HO lines was 840 g kg^{-1}. He indicated that the greater stability of the HO lines would be an advantage over other sources of increased oleate concentration (Rahman et al., 1994; Takagi and Rahman, 1995). His transgenic lines yielded on average 3665 kg ha^{-1}, which was comparable to the average of the elite check cultivars of 3564 kg ha^{-1}.

Scherder and Fehr (2008) compared 27 mid-oleate/low-linolenate lines to 27 normal-oleate/low-linolenate lines from three populations. The mid-oleate trait was obtained from the mutant M23 (Rahman et al., 1994). They found a significantly lower yield of 15%, 11%, and 9% in the mid-oleate/low-linolenate (MO) lines compared with the normal-oleate/low-linolenate (CO) lines in the three populations. When selecting the top 10 yielding lines in each population, only one line among the three populations was of the MO type. Averaged across the three populations, they found a significant reduction in oil concentration of 7 g kg^{-1} and seed weight of 8 mg $seed^{-1}$ of the MO lines compared with the CO lines. They suggested that the overlap in the distributions for oil concentration and seed weight would permit development of MO lines similar to that of CO. They indicated the primary challenge in developing MO lines would be to overcome the yield reduction associated with using M23 as the source of elevated oleate.

Bachlava et al. (2008) studied the correlations of oleate concentration with agronomic traits in three single-cross populations. The parents used to develop the populations were N98-4445A (563 g kg^{-1} oleate, 29 g kg^{-1} linolenate) , Satelite (low-linolenate, low-palmitate), N97-3363-3 (528 g kg^{-1} oleate, 29 g kg^{-1} linolenate) , and PI 423893 (306 g kg^{-1} oleate). The three populations were N98-4445A x Satelite, N97-3363-3 x PI 423893, and N98-4445A x PI 423893. They found a significant negative correlation between oleate concentration and yield in the populations they used. Oleate concentration was significant and negatively correlated with linoleate, linolenate, and palmitate. Palmitate and stearate concentrations were significant and positively correlated. They indicated that the negative correlation between yield and oleate concentration could hinder development of high-yielding, mid-oleate cultivars.

Graef et al. (2009) evaluated the agronomic performance of the transgenic event 335-13. They compared the performance of four homozygous T_2-derived lines with its transformed parent A3237, and the elite genotypes NE2801, NE3001, RMLPC1-311-128, and U98-307917. They tested the lines over eight environments with four replications at each environment. The T_2-derived lines produced soybean oil with mean concentrations of 32 g kg^{-1} palmitate, 25 g kg^{-1} stearate, 870 g kg^{-1} oleate, 14 g kg^{-1} linoleate, and 33 g kg^{-1} linolenate. The mean yield of the transformed lines was 3525 kg ha^{-1} and the mean yield of A3237, the parent used for transformation, was 3521 kg ha^{-1}. Mean maturity, height, lodging, and seed weight were very similar between the transformed lines and their parent. They concluded that the agronomic performance of soybean lines with the 335-13 HO transgenic event was equivalent to their transformed parent A3237.

Walker et al. (1998) studied the agronomic and seed traits of 27 reduced- linolenate lines (<30 g kg^{-1} linolenate) and 27 normal-linolenate lines (>70 g kg^{-1} linolenate) from three different

populations. The reduced linolenate lines were homozygous for the *fan1*(A5) and *fan2*(*A23*) alleles. They found no significant difference in mean yield between the reduced- and normal-linolenate lines for two of the populations, while the reduced-linolenate lines in the third population had a mean yield 192 kg ha^{-1} less than the normal lines. No consistent differences were observed for other traits measured. Due to the inconsistent results across populations, they suggested that multiple reduced- and normal-linolenate parents should be used in development of elite cultivars.

Ross et al. (2000) studied the agronomic and seed traits of 27 1%-linolenate (<20 g kg^{-1} linolenate) lines and 27 2%-linolenate (>20 g kg^{-1} linolenate) lines of three populations. Averaged across the three populations, the mean yield of the 1%-linolenate lines was 92 kg ha^{-1} less than the 2%-linolenate lines. Two of the populations did not have significant differences in mean yield between 1%- and 2%-linolenate lines, while the mean yield of the 1%-linolenate lines was significantly lower than the 2%-linolenate lines in the third population. Differences for other agronomic traits were minimal. They indicated that the lack of major differences between 1%- and 2%-linolenate lines would allow development of acceptable 1%-linolenate cultivars.

Environmental Stability of Oleate and Linolenate

Primomo et al. (2002) studied the influence of locations and years of production on the fatty acid concentration of RG10 with a linolenate concentration of 22 g kg^{-1}, C1640 with a linolenate concentration of 44 g kg^{-1}, RG9 with an oleate concentration of 340 g kg^{-1}, and AN145-66 with an oleate concentration of 313 g $kg^{-1}$and linolenate concentration of 38 g kg^{-1}. Genotypes were significantly different from each other across years for all fatty acids. Linolenate and oleate tended to have a greater sensitivity to the environment than any of the

other fatty acids. The genotype x location and genotype x year x location interactions had the most impact on oleate, linoleate, and linolenate concentrations. Palmitate tended to be the most stable of any of the fatty esters.

Scherder et al. (2008) compared the stability of 26 mid-oleate lines with different concentrations of saturated fatty acids and linolenate concentrations. M23 was the mid-oleate source for the 26 lines (Rahman et al., 1994). They found significant differences in the mean oleate concentration across years and genotypes. Their ranking of highest to lowest mean oleate concentration of the lines was mid-oleate/low-saturate (590 g kg^{-1}), mid-oleate/low-saturate/low-linolenate (557 g kg^{-1}), and mid-oleate/low-linolenate (521 g kg^{-1}). Their mid-oleate lines that produced the largest mean oleate concentration also tended to have the greatest variability in oleate concentration across environments.

Based on the previous agronomic and stability studies involving high-oleate and reduced linolenate, HONL lines developed from the DP-305423-1 event would not be expected to be different than NONL lines. The *fan1*(C1640) and *fan3*(RG10) alleles in the HOLL lines also would not be expected to cause significant differences in agronomic and seed traits.

MATERIALS AND METHODS

Lines of the HOLL, HONL, and NONL classes compared in this study were obtained from each of four single-cross populations developed by crossing one HOLL parent to four NONL cultivars. All of the parents were developed by Pioneer. The HOLL parent SP16410155 was homozygous for the transgene DP-305423-1 (Kinney et al., 2008), the Roundup Ready® transgene (*Gly*^{R})(GTS 40-3-2) (Shah et al., 1993), and the low-linolenate alleles *fan1*(C1640) (Wilcox et al., 1984) and *fan3*(RG10) (Stojsin et al., 1998).

The four cultivars used as parents were 92Y80, 93Y02, 93Y11, and 93Y20. They were homozygous for the Roundup Ready® transgene and had resistance to the soybean cyst nematode (SCN) [*Heterodera glycines* Ichinohe] from PI 88788.

The crosses were made in June 2007 at the Pioneer Research Center at Dallas Center, IA. The HOLL parent was used as the male and the cultivars were used as the females. The cross of 92Y80 x SP16410155 was designated SP21720973 and will be referred to hereinafter as Pop1; 93Y02 x SP16410155 was designated SP21720974 (Pop2); 93Y11 x SP16410155 as SP21720957 (Pop3); and 93Y20 x SP16410155 as SP21720976 (Pop4). There were 12 F_1 seeds obtained for Pop1, 10 seeds for Pop2, 14 seeds for Pop3, and 3 seeds for Pop4.

The F_1 seeds of the four populations were planted in October 2007 at the Pioneer Research Station at Salinas, PR. The F_1 plants of Pop1 were confirmed by flower color. The F_1 plants of Pop2, Pop3, and Pop4 were confirmed with a molecular marker associated with the HO transgene. The hybrid plants of each population were harvested in bulk.

There were 800 F_2 seeds of each population planted at Salinas in January 2007. The seeds of each population were planted in two-row plots 12.2 m long at a rate of 33 seeds m^{-1}. Selection of F_2 plants was based on DNA marker analysis for the HO transgene and alleles for

resistance to SCN. The F_2 plants homozygous or heterozygous for the HO transgene and those that were homozygous for alleles conferring SCN resistance were identified by molecular marker analysis and harvested in bulk for each population.

A random sample of 1,200 F_3 seeds of each population was planted in the field at Dallas Center in 2008. The seeds of each population were planted in 12-row plots 5.33 m long with a row spacing of 0.76 m at a rate of 19 seeds m^{-1}. All of the F_3 plants were analyzed with DNA markers for the HO transgene and the SCN resistance alleles. Due to the HO molecular marker being a dominant marker, homozygous and heterozygous HO genotypes were unable to be differentiated. Gas chromatography was used later to determine homozygous HO, *fan1*(C1640), *Fan1*, *fan3*(RG10), and *Fan3* F_3 plants. Therefore, selected F_3 plants were homozygous for SCN resistance; homozygous or heterozygous for the *fan1*(C1640) allele or the *Fan1* allele; homozygous or heterozygous for the *fan3*(RG10) allele or the *Fan3* allele; homozygous or heterozygous for the HO transgene: or homozygous for absence of the HO transgene. A total of 1,117 F_3 plants from the four populations were individually harvested. In November 2008, the 1,117 $F_{3:4}$ lines were planted at the Pioneer Research Station at Viluco, Chile. The 22 seeds of each line and check cultivar were planted in a one-row plot 0.91 m long with a row spacing of 0.76 m. The check cultivars were 92M61, 92Y20, 93M61, 93M42, 93Y70, 92Y80, 93M11, 93Y11, and 92Y30, all of which have normal oleate and linolenate concentration. The checks were chosen based on their maturity and as a comparison in identifying elite lines. Maturity notes were taken on the plots to ensure that the range among the lines to be tested in 2009 was 1 d for each of the populations. Each of the lines and checks were harvested in bulk.

During the time when the $F_{3:4}$ lines were under production in Chile, a five-seed bulk from the F_3 plants was analyzed for fatty ester composition by gas chromatography to confirm that

they had been put in the proper class during the summer of 2009. The fatty ester compositions were determined with a Hewlett-Packard gas chromatograph equipped with a ZB- wax column (Phenomenex, Torrance, CA) according to the methodology described by Butte et al. (1982) and Dolde et al. (1999). Values were determined as percentages that were converted to g kg^{-1} by multiplying the percentages by 10. The F_3 plants in the HOLL class had oleate concentrations ≥750 g kg^{-1} and ranged from 753 g kg^{-1} to 813 g kg^{-1} and linolenate concentrations ≤30 g kg^{-1} and ranged from 18 g kg^{-1} to 30 g kg^{-1}; those of the HONL class had oleate concentrations ≥750 g kg^{-1} and ranged from 754 g kg^{-1} to 811 g kg^{-1} and linolenate concentrations ≥50 g kg^{-1} and ranged from 50 g kg^{-1} to 72 g kg^{-1}; and those of the NONL class had oleate concentrations ≤300 g kg^{-1} and ranged from 184 g kg^{-1} to 264 g kg^{-1} and linolenate concentrations ≥67 g kg^{-1} and ranged from 67 g kg^{-1} to 100 g kg^{-1}. The homogeneity of each line for the fatty ester phenotype was confirmed by analyzing 11 individual seeds from each. The oleate and linolenate concentration of all seeds analyzed for a given line had to be similar to consider them homogeneous. Once the $F_{3:4}$ lines were harvested, a 5-seed bulk sample was analyzed by gas chromatography (Butte et al., 1982; Dolde et al., 1999) to reconfirm their classification.

In May 2009, an experiment was planted for each population with the $F_{3:5}$ seed of each line harvested in Chile. The seed for all of the check cultivars included in the experiment was from Chile, except for 92Y80 in Pop1, 93M11 in Pop2, 93Y11 in Pop3, and 93Y20 in Pop4 that were obtained from production in Iowa. Check cultivars were grown to identify lines that had potential for commercial use; however, they were not included in the analyses of the data for the study. There were 14 HOLL, 14 HONL, 14 NONL lines, and 6 checks (92M61, 92Y80, 93M11, 93M42, 92Y80 US, and 92Y30) in Pop1; 16 HOLL, 16 HONL, 16 NONL lines and 6 checks (92M61, 92Y80, 93M11, 93M42, 93M11 US, and 93Y11) in Pop2; 17 HOLL, 17 HONL, 17

NONL lines and 6 checks (92M61, 92Y80, 93M11, 93M42, 93Y11 US, and 93Y11) in Pop3; and 24 HOLL, 24 HONL, 24 NONL lines and 6 checks (92M61, 92Y80, 93M11, 93M42, 93Y20 US, and 93M61) in Pop4.

Each of the experiments was planted in a randomized complete-block design with two replications at environments suitable for the maturity of the lines. Pop1 was grown at Conrad, Dallas Center, and, Denison, IA; Princeton, IL; and Napoleon, OH. The other three populations were planted at Atlantic, Hedrick, and Washington, IA; Princeton, IL; and Napoleon, OH. The planting dates were 1 May at Princeton, 14 May at Denison, 18 May at Napoleon, 19 May at Conrad, 21 May at Atlantic, 23 May at Dallas Center, 25 May at Washington, and 1 June at Hedrick. The soil type at Atlantic is a Marshall silty clay loam (fine-silty, mixed, mesic Typic Hapludolls); at Conrad is a Tama silty clay loam (fine-silty, mixed, superactive, mesic Typic Agriudolls); at Dallas Center is a Nicollet loam (fine-loamy, mixed, superactive, mesic Aquic Hapludolls); at Denison is a Kennebec silt loam (fine-silty, mixed mesic Cumulic Hapludolls); at Hedrick is a Taintor silty clay loam (fine, montmorillonitic, mesic Typic Argiaquolls); at Washington is a Kalona silty clay loam (fine, montmorillonitic, mesic Typic Haplaquolls); at Princeton is a Muscatune-Buckhart silt loam (fine-silty, mixed, superactive, mesic Aquic Argiudolls); and at Napoleon is a Gilford fine sandy loam (course-loamy, mixed, mesic Typic Haplaquolls). The plots were two rows 4.57 m long with 0.76 m between rows within and between adjacent plots. The seeding rate was 26 seeds m^{-1}.

Each plot grown in Iowa was evaluated for maturity, lodging, plant height, grain yield, protein concentration, oil concentration, seed weight, and fatty ester profile. Each plot grown at Princeton and Napoleon was evaluated only for grain yield. Maturity was recorded as d after 31 August when 95% of the pods on the main stem had reached their mature color. Lodging was a

visual score from 1 (all plants erect) to 5 (all plants prostrate). Plant height was the length in cm from the soil surface to the terminal node. All plots were harvested with a plot combine (Almaco, Nevada, IA) and weight and moisture were determined. Yields of the plots were adjusted to 130 g kg^{-1} moisture. Protein and oil concentrations were determined using an Infratec 1221 near-infrared whole grain analyzer (NIR) (Tecator AB, Hooganas, Sweden) and adjusted to 130 g kg^{-1} moisture. Seed weight was determined in mg $seed^{-1}$ from a random sample of 200 whole seeds. The fatty ester concentration of each plot was determined by analyzing two five-seed bulk samples of each plot by gas chromatography (Butte et al., 1982; Dolde et al., 1999).

To determine if the protein and oil concentrations obtained by the NIR method were influenced by differences in the fatty ester concentrations among lines, 10 random lines within each class from Atlantic, IA were analyzed for protein and oil concentrations by Eurofins (Des Moines, IA). Eurofins used the Kjeldahl method to obtain the protein concentration and the solvent extraction method to obtain the oil concentration. The protein and oil concentrations obtained from Eurofins were compared to the NIR method. The maximum differences between the solvent extraction and NIR methods for oil concentration were 10 g kg^{-1} for the HOLL class, 7 g kg^{-1} for the HONL class, and 8 g kg^{-1} for the NONL class (Appendix D). The phenotypic correlation coefficients between the solvent extraction and NIR methods for oil concentration were 0.84 for the HOLL class, 0.78 for the HONL class, and 0.80 for the NONL class. The maximum differences between the Kjeldahl and NIR methods for protein concentration were 14 g kg^{-1} for the HOLL class, 25 g kg^{-1} for the HONL class, and 9 g kg^{-1} for the NONL class. The phenotypic correlation coefficients between the Kjeldahl and NIR methods for protein concentration were 0.85 for the HOLL class, 0.62 for the HONL class, and 0.76 for the NONL

class. All correlations were significant at the 0.05 probability level. The significant correlations indicated that the NIR method was reliable for assessing the protein and oil concentrations of lines in the study.

STATISTICAL ANALYSIS

All data were analyzed using the general linear model (GLM) procedure of SAS version 9.2 (SAS Institute, 2008). Environments and replications were considered random, and the HOLL, HONL, and NONL lines were considered fixed. A single replication for Pop3 at Washington was excluded from the analyses of variance due to flooding. The sums of squares for genotypes were partitioned into HOLL lines, HONL lines, NONL lines and Classes. The mean squares for the genotype x environment interactions of each class were used to test the significance of each of the partitioned components of genotypes by an F-test. The mean squares for the error of each class were used to test the significance of each of the partitioned components of the genotype x environment interaction by an F-test. Differences among the means of the three classes were determined by Tukey's honestly significant difference test (Tukey, 1949). The phenotypic correlation coefficients between oleate concentration and the other traits were calculated with the correlation procedure (CORR) of SAS (SAS Institute, 2008) on the basis of the mean performance of lines across the Iowa environments for each population.

The linear additive model used for the analysis of variance of agronomic and seed traits across environments for each population was:

$$Y_{ijk} = \mu + E_i + R_{(i)j} + G_k + GE_{ik} + RG_{(i)jk}$$

where,

Y_{ijk} = the observed value of the k^{th} genotype, j^{th} replication, and the i^{th} environment,

μ = the overall mean,

E_i = the effect of the i^{th} environment,

$R_{(i)j}$= the effect of the j^{th} replication within the i^{th} environment,

G_k = the effect of the k^{th} genotype,

GE_{ik} = the effect of the interaction between the i^{th} environment and the k^{th} genotype, and $RG_{(i)jk}$= the error associated with the ijk^{th} observation.

Table 1. Analysis of variance and expected mean squares for each population at multiple environments.

Sources of Variation	Degrees of Freedom	Expected Mean Squares
Environments (E)	(e-1)	$\sigma^2_e + g\sigma^2_R + gr\sigma^2_E$
Replications/E (R/E)	e(r-1)	$\sigma^2_e + g\sigma^2_R$
Genotypes (G)	(g-1)	$\sigma^2_e + \sigma^2_{RG} + r\sigma^2_{GE} + er\Phi_G$
HONL	(h-1)	$\sigma^2_e + \sigma^2_{R(HONL)} + r\sigma^2_{(HONL)E} + er\Phi_{HONL}$
HOLL	(hl-1)	$\sigma^2_e + \sigma^2_{R(HOLL)} + r\sigma^2_{(HOLL)E} + er\Phi_{HOLL}$
NONL	(n-1)	$\sigma^2_e + \sigma^2_{R(NONL)} + r\sigma^2_{(NONL)E} + er\Phi_{NONL}$
Class	2	$\sigma^2_e + \sigma^2_{R(Class)} + r\sigma^2_{(CLASS)E} + er\Phi_{CLASS}$
G x E	(e-1)(g-1)	$\sigma^2_e + \sigma^2_{RG} + r\sigma^2_{GE}$
HONL x E	(e-1)(h-1)	$\sigma^2_e + \sigma^2_{R(HONL)} + r\sigma^2_{(HONL)E}$
HOLL x E	(e-1)(hl-1)	$\sigma^2_e + \sigma^2_{R(HOLL)} + r\sigma^2_{(HOLL)E}$
NONL x E	(e-1)(n-1)	$\sigma^2_e + \sigma^2_{R(NONL)} + r\sigma^2_{(NONL)E}$
Class x E	(e-1)(2)	$\sigma^2_e + \sigma^2_{R(Class)} + r\sigma^2_{(CLASS)E}$
Error	e(r-1)(g-1)	$\sigma^2_e + \sigma^2_{RG}$
HONL Error	e(r-1)(h-1)	$\sigma^2_e + \sigma^2_{R(HONL)}$
HOLL Error	e(r-1)(hl-1)	$\sigma^2_e + \sigma^2_{R(HOLL)}$
NONL Error	e(r-1)(n-1)	$\sigma^2_e + \sigma^2_{R(NONL)}$
Class Error	e(r-1)(c-1)	$\sigma^2_e + \sigma^2_{R(Class)}$
Total	erg-1	

The linear additive model for the analysis of variance of agronomic and seed traits for each environment was:

$$Y_{ij} = \mu + R_i + G_j + RG_{ij}$$

where,

Y_{ij} = the observed value of the j^{th} genotype within the i^{th} replication,

μ = the overall mean,

R_i = the effect of the i^{th} replication,

G_j = the effect of the j^{th} genotype, and

RG_{ij} = the error associated with the ij^{th} observation.

Table 2. Analysis of variance and expected mean squares for each population at an individual environment.

Sources of Variation	Degrees of Freedom	Expected Mean Squares
Replications (R)	(r-1)	$\sigma^2_e + g\sigma^2_R$
Genotypes (G)	(g-1)	$\sigma^2_e + \sigma^2_{RG} + r\Phi_G$
HONL	(h-1)	$\sigma^2_e + \sigma^2_{R(HONL)} + r\Phi_{HONL}$
HOLL	(hl-1)	$\sigma^2_e + \sigma^2_{R(HOLL)} + r\Phi_{HOLL}$
NONL	(n-1)	$\sigma^2_e + \sigma^2_{R(NONL)} + r\Phi_{NONL}$
Class	1	$\sigma^2_e + \sigma^2_{R(Class)} +$
Error	(r-1)(g-1)	$\sigma^2_e + \sigma^2_{RG}$
HONL Error	(r-1)(h-1)	$\sigma^2_e + \sigma^2_{R(HONL)}$
HOLL Error	(r-1)(hl-1)	$\sigma^2_e + \sigma^2_{R(HOLL)}$
NONL Error	(r-1)(n-1)	$\sigma^2_e + \sigma^2_{R(NONL)}$
Class Error	(r-1)(c-1)	$\sigma^2_e + \sigma^2_{R(Class)}$
Total	rg-1	

The standard error of the mean (SEM), coefficient of variation (CV), least significant difference (LSD) at probability levels of 0.01 and 0.05, Tukey's honestly significant difference (HSD) at the 0.05 probability level, and phenotypic correlations (CORR) were calculated as:

$$SEM = \sqrt{\frac{MSE}{n}}$$ (Lorenzen and Anderson, 1993)

$$CV\ (\%) = \frac{\sqrt{MSE}}{\bar{x}}(100)$$

$$LSD = t_{\alpha}\sqrt{\frac{2MSE}{n}}$$ (Fisher, 1949)

$$HSD = q_{\alpha}\sqrt{\frac{MSE}{n}}$$ (Tukey, 1949)

where,

MSE = the mean square error for the genotype x environment interaction was used in calculation of the SEM, LSD, and HSD for comparison of the means of individual genotypes and the means of classes across environments. The overall error term was used in calculating the SEM, LSD, and HSD for comparison of the means of individual genotypes and the means of classes at individual environments,

$\bar{x}$ = the mean of all lines for a trait,

n = the number of observations used to compute the mean value of a genotype or class, and

t = the critical t-value for a 0.01 or 0.05 probability level based on Student's t-distribution,

q= the critical q-value for a 0.01 or 0.05 probability level based on the Studentized range distribution.

$$\text{CORR}= \frac{\sum\left(x-\bar{x}\right)\left(y-\bar{y}\right)}{\sqrt{\sum\left(x-\bar{x}\right)^2\sum\left(y-\bar{y}\right)^2}}$$ (Falconer and Mckay, 1996)

where,

x = the mean of an individual line for a trait,

$\bar{x}$ = the overall mean of lines for a trait,

y = the mean oleate concentration of an individual line, and

$\bar{y}$ = the overall mean of lines for oleate concentration.

RESULTS

The fatty ester profiles for the HOLL, HONL, and NONL classes differed in all of the populations (Table 1). The mean oleate concentrations of the HOLL and HONL classes were not significantly different, but both classes were significantly greater in oleate than the NONL. The mean linolenate concentrations were least for the HOLL class, intermediate for HONL, and greatest for NONL in all of the populations. The increase in oleate and reduction in linolenate for the HOLL class was associated with a significantly greater linoleate concentration than that of the HONL. Both classes had significantly less linoleate than the NONL. The mean concentrations of palmitate for the HOLL and HONL classes differed by a maximum of 2 g kg^{-1} in the four populations. Both classes had significantly less palmitate than that of the NONL. Although differences among the three classes in the mean stearate concentrations were significant in all of the populations, the maximum difference among the classes was only 6 g kg^{-1} in Pop2.

The mean yields of the HOLL and HONL classes were not significantly different in any of the populations (Table 1). The mean yields of the HOLL class were significantly less than the NONL class in all of the populations, and mean yields of the HONL class were significantly less than the NONL class in three of the four populations. The differences between the HOLL and NONL classes were 4.5% in Pop1, 4.6% in Pop2, 4.2% in Pop3, and 4.7% in Pop4; and the differences between the HONL and NONL classes were 3.6% for Pop1, 3.3% for Pop2, 2.1% in Pop3, and 3.1% in Pop4. The phenotypic correlation coefficients between oleate and seed yield were significant across all lines in three of the four populations (Table 2). The feasibility of selecting lines with high yield from the three classes was evaluated by ranking the top 10 lines in each of the populations (Table 3). None of the top 10 lines within a population were

significantly different from each other based on Tukey's honestly significant difference at the 0.05 probability level. Of the 40 lines in the four populations, 25% were HOLL, 15% were HONL, and 60% were NONL. This indicated that it should be possible to develop HOLL and HONL lines comparable in yield to NONL lines; however, their frequency would be less than that of NONL lines in the same segregating population.

The significant variation among HOLL lines for oleate concentration in two of the four populations and among HONL lines in all of the populations indicated the presence of modifying genes (Table 1). The role of modifiers in determining the genetic potential of a line for oleate concentration would be consistent with studies by Alt et al. (2005) and Scherder et al. (2008) with the mutant *ol* allele for mid-oleate derived from M23. Genetic variation associated with modifiers would make it possible to select among HO lines in a segregating population for those with the highest oleate concentrations. The lack of significant HOLL lines x environment interactions for oleate in any of the populations and a significant HONL lines x environment interaction in only one population indicated that selection should be effective in a limited number of environments for identifying lines with greatest HO concentrations. Another method used to determine the consistency of oleate concentration across environments was to compare their ranking for oleate concentration at individual environments for the HOLL class of Pop1 (Table 6). Lines 9 and 17 had the highest oleate concentrations at the three environments and the highest mean across environments. However, the top seven lines (50%) based on the mean across environments were not necessarily in the top half of the lines at all environments. Correlations were computed on the rank of the lines and their oleate concentrations among the three environments. The correlations were significant between Conrad and Denison and between Dallas Center and Denison, but not between Conrad and Dallas Center (Table 7 and 8). The

results suggested that a minimum of two environments would be needed to select lines with greatest oleate concentration.

Additional research at multiple environments would be useful for determining the stability of HO lines differing in oleate concentration across environments. To obtain a sufficient understanding of the stability of HO lines, an experiment with multiple HO (DP-305423-1), conventional, and mid-oleate (M23) lines should be evaluated over a minimum of 10 environments. The conventional and mid-oleate lines would provide a basis for determining the stability of the HO (DP-305423-1) trait compared with the two types that are or have been grown commercially.

The differences in the mean maturity of lines in the three classes were small and not consistent among the four populations (Table 1). The similarity among the classes was expected because lines within a limited maturity range were chosen for the study to minimize its possible influence on differences among the three classes for other traits. Differences in mean plant height and lodging scores among the three classes were small and inconsistent for the four populations. The ranges in values among lines for the two traits were similar for the three classes, which indicated that it should be possible to develop HOLL and HONL cultivars comparable to that of the NONL cultivars.

The HONL class had the greatest mean protein concentration, the HOLL class was intermediate, and the NONL class had the lowest concentration in the four populations (Table 1). The maximum difference among the classes was only 9 g kg^{-1} in Pop3. The HOLL class had significantly lower mean oil concentration compared with the NONL class, but the maximum difference between the two classes was only 6 g kg^{-1} in Pop4. Differences among the classes for seed weight were not consistent among the populations. The overlap in the distributions of the

lines in the three classes for protein, oil, and seed weight indicated that cultivars with comparable characteristics could be developed for each class from a segregating population.

DISCUSSION

The mean oleate concentration for all the HOLL and HONL classes averaged across the four populations of 785 g kg^{-1} was slightly greater than the 765 g kg^{-1} oleate for the DP-305423-1 transgene reported by Kinney et al. (2008). The oleate values for lines with the transgene DP-305423-1 in both studies were less than the 850 g kg^{-1} reported by Kinney (1996) for the event 260-05 and >850g kg^{-1} for the event 335-13 reported by Graef et al. (2009). The different seed specific promoters and insertion sites of the constructs used for the 260-05 and DP-305423-1 events are possible reasons for the difference in oleate concentration between the two events. The greater oleate in the event 335-13 may have been due to use of a construct for transformation that included a gene for reduced palmitate. An increase in oleate with a decrease in palmitate would be consistent with the negative correlations coefficients observed between the two traits in our study (Table 2).

Kinney (1996) compared the yields of elite conventional cultivars and lines with those of lines containing the 260-05 event during 2 years. The conventional entries yielded about 3564 kg ha^{-1} and those with the 260-05 event yielded 3665 kg ha^{-1} (Kinney, 1996). He concluded that the changes in fatty-acid phenotype and the process used for transformation did not negatively affect the yield of the 260-05 HO event.

Graef et al. (2009) evaluated the agronomic performance of the transgenic event 335-13. They compared four homozygous T_2-derived lines with its transformed parent A3237, and four elite conventional cultivars and lines. They tested the lines at eight environments with four replications at each environment. The mean yield was 3525 kg ha^{-1} for the transformed lines, 3521 kg ha^{-1} for the A3237 parent, and 3900 kg ha^{-1} for the elite cultivars and lines. They

indicated that the 335-13 transgenic event did not compromise the agronomic performance of soybean lines.

In an application to the United States Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS) for de-regulation of the HO event DP-305423-1, Pavely (personal communication, 2007) reported on tests conducted across four environments with nine replications of the DP-305423-1 line and three replications of the untransformed parent Jack (PI 540556) at each environment. She reported that the T_8 DP-305423-1 soybean line yielded 4.8% less than Jack. This difference in mean yield was not significant (p=0.14). The 4.8% reduction in yield associated with the DP-305423-1 line in his study was similar to 4.5% yield reduction in the mean yield of the HONL lines compared to NONL lines in my study. In the same application, she also reported on an experiment that compared BC_1F_5 near isogenic lines that were positive or negative for the HO event DP-305423-1. The method used to develop the lines or the number of lines tested for each type was not specified. The experiment was grown at six environments with 3 replications at each environment. She reported from this experiment that the near isogenic lines positive for the HO event had a mean yield of 2313 kg ha^{-1}, while the near isogenic lines negative for the HO event had a mean yield of 2327 kg ha^{-1}. The difference among the positive and negative near isogenic lines was not significant (p=0.90).

The cause of the lower mean yields of lines with the DP-305423-1 event in this study will require further research to determine if it resulted from the construct that was inserted, the site of insertion, or undesirable linkages between the transgene and other genomic components. The HO parent in all of the populations was SP16410155. Future research should involve crosses with other HO parents that have different genomic makeups in the region of the transgene than that of DP-305423-1.

The influence of the HO transgene on yield was less than that reported by Scherder and Fehr (2008) for lines with the mutant *ol* allele for mid-oleate (MO) from M23. They evaluated 27 MO lines and 27 conventional (CO) lines from each of three segregating populations. Averaged across populations, the MO lines yielded 12% less than the CO lines. Of the 10 top lines in each population, all of them were from the CO class in two populations and nine were from the CO class in the third population.

Selection of HOLL cultivars with the HO transgene DP-305423-1 and the *fan1*(C1640) and *fan3*(RG10) alleles for reduced linolenate from segregating populations would require more resources than selection for only the transgene in HONL cultivars. The additional resources would be justified if the HOLL oil was preferred by end users. One potential advantage of a HOLL oil compared with a HONL oil may be greater oxidative stability. Although linoleate was greater in the HOLL than the HONL oil, replacement of linolenate with linoleate would be expected to increase the overall oxidative stability (Frankel, 1985). A second potential advantage of the HOLL oil associated with its greater linoleate may be the improved flavor of prepared foods. Su and White (2004a) indicated that low-linolenate soybean oil produced a more desirable fried flavor than HONL or NONL soybean oil, and that the elevated linoleate was responsible for the desirable fried flavor. Warner and Gupta (2005) indicated that the lower concentration of linoleate than linolenate in the high-oleate oil they tested may have been responsible for the undesirable fishy flavors that were observed in fried potato chips. Future research will be necessary to compare the functional properties of the HOLL and HONL oils.

Table 3. Mean and range for agronomic and seed traits of high-oleate/low-linolenate, high-oleate/normal-linolenate, and normal-oleate/normal-linolenate lines from four soybean populations grown in 2009.

		Population 1		Population 2		Population 3		Population 4	
Trait	Class†	Mean‡	Range	Mean	Range	Mean	Range	Mean	Range
Oleate	HOLL	776 a	741-798**	786 a	768-807§ns	790 a	774-814ns	791 a	756-817**
(g kg^{-1})	HONL	774 a	732-801**	781 a	693-808**	794 a	755-813*	788 a	728-809**
	NONL	222 b	206-247*	224 b	202-286**	231 b	208-272**	228 b	206-275**
Linolenate	HOLL	24 a	21-27*	24 a	20-26**	23 a	19-26**	24 a	21-28**
(g kg^{-1})	HONL	54 b	50-62**	56 b	50-67**	55 b	48-65**	57 b	50-65**
	NONL	76 c	43-88**	75 c	63-88**	78 c	66-93**	72 c	43-84**
Linoleate	HOLL	84 a	67-117**	83 a	61-101ns	78 a	60-92ns	78 a	60-108**
(g kg^{-1})	HONL	59 b	38-105**	54 b	33-142**	47 b	33-74*	48 b	34-90**
	NONL	552 c	519-583**	555 c	487-584**	549 c	512-572**	559 c	506-594**
Palmitate	HOLL	71 a	66-76**	66 a	60-71**	66 a	61-73**	64 a	60-70**
(g kg^{-1})	HONL	70 a	65-79**	66 a	61-71**	64 b	59-67**	65 b	57-70**
	NONL	106 b	97-116**	99 b	93-105**	98 c	93-103**	95 c	91-101**
Stearate	HOLL	45 a	40-52**	41 a	35-45**	43 a	38-46**	43 a	35-50**
(g kg^{-1})	HONL	43 b	37-49**	43 b	39-49**	40 b	35-45**	42 b	37-49**
	NONL	44 ab	40-51**	47 c	41-55**	44 c	37-54**	45 c	38-54**
Yield	HOLL	3874 a	3092-4264**	3937 a	2981-4329**	3840 a	3271-4265**	3863 a	3165-4203**
(kg ha^{-1})	HONL	3908 a	3688-4062ns	3990 a	3644-4192**	3926 ab	3212-4243**	3929 a	3448-4395**
	NONL	4055 b	3724-4306**	4127 b	3870-4416**	4010 b	3661-4229**	4055 b	3541-4312**
Maturity	HOLL	28 a	22-32**	28 a	24-31**	26 a	23-30**	27 a	24-30**
(days¶)	HONL	27 b	21-32**	27 b	25-31**	27 b	25-31**	27 a	23-32**
	NONL	26 c	20-30**	27 b	24-32**	27 b	24-32**	28 b	25-34**
Height	HOLL	100 a	91-108**	90 a	80-98**	92 a	80-104**	91 a	85-98**
(cm)	HONL	103 b	90-111**	90 a	81-94**	93 ab	81-106**	92 a	83-103**
	NONL	102 b	93-108**	90 a	80-96**	94 b	88-105**	95 b	86-102**
Lodging	HOLL	2.0 a	1.5-3.1**	1.7 a	1.4-2.1**	1.6 a	1.2-2.4**	1.8 a	1.3-2.3**
(score #)	HONL	2.4 b	1.3-3.6**	1.6 ab	1.3-1.8ns	1.7 a	1.2-2.7**	1.8 a	1.3-2.3**
	NONL	2.1 a	1.1-3.2**	1.5 b	1.3-1.8ns	1.7 a	1.0-2.4**	1.8 a	1.3-2.8**
Protein	HOLL	355 a	348-364**	357 a	348-367**	360 a	353-372ns	355 a	346-363**
(g kg^{-1} ††)	HONL	358 b	347-372**	358 a	351-371**	363 b	356-373**	357 b	350-364**
	NONL	352 c	341-369**	352 b	344-359**	354 c	345-360**	351 c	340-360**
Oil	HOLL	178 a	172-186**	172 a	167-178**	178 a	172-187**	176 a	171-183**
(g kg^{-1})	HONL	179 a	171-185**	172 a	168-182**	177 b	169-184**	177 b	170-185**
	NONL	183 b	175-191**	177 b	173-182**	182 c	174-191**	182 c	175-188**
Seed Wt.	HOLL	178 a	162-196**	171 a	153-186**	186 a	170-207**	186 a	170-206**
(mg sd^{-1})	HONL	183 b	167-218**	176 b	166-186**	183 b	167-197**	191 b	178-206**
	NONL	183 b	169-196**	178 b	168-193**	181 c	164-195**	190 b	169-205**

† HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines.

‡ = Means within a column and trait followed by the same letter were not significantly different at the 0.05 probability level based on Tukey's honestly significant difference (Tukey, 1949).

* Significant differences among lines within a class at the 0.05 probability level.

** Significant differences among lines within a class at the 0.01 probability level.

§ns = differences among lines within a class were not significant at the 0.05 probability level.

¶ Days after 31 August.

Score 1 (all plants erect) to 5 (all plants prostrate).

†† Protein and oil concentration on a moisture basis of 130 g kg^{-1}.

Table 4. Phenotypic correlation coefficients between oleate concentration and agronomic and seed traits for high-oleate/low-linolenate, high-oleate/normal-linolenate, and normal-oleate/normal-linolenate lines in four soybean populations evaluated during 2009.

		Population			
Trait	Class†	1	2	3	4
Yield, kg ha^{-1}	HOLL	0.36	-0.11	-0.27	0.14
	HONL	-0.06	-0.27	0.26	0.03
	NONL	0.52*	-0.20	-0.13	0.06
	All	-0.31*	-0.35**	-0.26	-0.31**
Linolenate, g kg^{-1}	HOLL	-0.46	-0.25	-0.40	-0.59**
	HONL	-0.38	-0.04	-0.55*	-0.41*
	NONL	0.11	0.24	-0.31	-0.21
	All	-0.77**	-0.76**	-0.79**	-0.72**
Palmitate, g kg^{-1}	HOLL	-0.43	-0.53*	-0.62**	-0.43*
	HONL	-0.67**	-0.35	-0.45	-0.61**
	NONL	-0.23	-0.25	-0.33	-0.04
	All	-0.98**	-0.98**	-0.98**	-0.98**
Stearate, g kg^{-1}	HOLL	-0.47	0.02	0.55*	-0.41*
	HONL	-0.12	-0.33	0.23	-0.48**
	NONL	-0.49	-0.04	0.46	0.59**
	All	-0.09	-0.62**	-0.29*	-0.34**
Linoleate, g kg^{-1}	HOLL	-0.95**	-0.93**	-0.93**	-0.95**
	HONL	-0.97**	-0.98**	-0.96**	-0.94**
	NONL	-0.69**	-0.91**	-0.87**	-0.87**
	All	-1.00**	-1.00**	-1.00**	-1.00**
Maturity, d	HOLL	-0.18	-0.11	-0.14	-0.19
	HONL	-0.19	-0.42	-0.34	-0.23
	NONL	0.21	-0.16	0.26	0.09
	All	0.21	0.09	-0.07	-0.18
Height, cm	HOLL	0.17	-0.27	0.05	-0.49**
	HONL	0.06	-0.34	-0.24	-0.26
	NONL	0.34	-0.28	-0.03	-0.15
	All	-0.03	-0.01	-0.10	-0.29**
Lodging, score	HOLL	-0.14	-0.21	0.01	-0.49**
	HONL	0.22	-0.21	-0.09	0.01
	NONL	0.12	-0.26	0.01	-0.06
	All	0.08	0.37**	-0.05	-0.08
Protein, g kg^{-1}	HOLL	0.10	0.00	-0.32	-0.25
	HONL	0.25	-0.02	0.04	-0.43*
	NONL	0.49	0.32	0.44	0.25
	All	0.30*	0.48**	0.61**	0.48**
Oil, g kg^{-1}	HOLL	0.50	0.13	0.30	0.48**
	HONL	0.40	-0.02	0.44	0.47*
	NONL	-0.14	-0.23	-0.32	-0.41*
	All	-0.44**	-0.61**	-0.37**	-0.59**
Seed Wt., mg sd^{-1}	HOLL	0.36	-0.29	0.09	-0.20
	HONL	0.37	0.18	0.23	0.16
	NONL	0.52*	-0.28	-0.01	0.43*
	All	-0.09	-0.26	0.23	-0.06

† HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines.

*Significant at the 0.05 probability level.

**Significant at the 0.01 probability level.

Table 5. Frequency of high-oleate/low-linolenate, high-oleate/normal-linolenate, and normal-oleate/normal-linolenate soybean lines among the 10 highest yielding lines in each of the four populations evaluated during 2009.

Population											
1			2			3			4		
Rank	Class†	Yield kg ha^{-1}	Rank	Class	Yield kg ha^{-1}	Rank	Class	Yield kg ha^{-1}	Rank	Class	Yield kg ha^{-1}
1	NONL	4306	1	NONL	4416	1	HOLL	4265	1	HONL	4395
2	NONL	4292	2	NONL	4396	2	HONL	4243	2	NONL	4312
3	NONL	4283	3	NONL	4387	3	NONL	4229	3	NONL	4244
4	HOLL	4264	4	NONL	4354	4	NONL	4218	4	NONL	4241
5	HOLL	4237	5	HOLL	4329	5	NONL	4193	5	NONL	4227
6	NONL	4233	6	NONL	4204	6	NONL	4187	6	HONL	4223
7	NONL	4222	7	HONL	4192	7	NONL	4136	7	HOLL	4203
8	HOLL	4198	8	NONL	4184	8	HONL	4113	8	HOLL	4199
9	NONL	4135	9	NONL	4183	9	HOLL	4112	9	NONL	4193
10	HOLL	4102	10	HONL	4160	10	HOLL	4107	10	NONL	4178
LSD‡		308			302			323			306

† HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines.

‡ = Least significant difference at the 0.05 probability level.

Table 6. Means and ranks for oleate concentration of 14 high-oleate/low-linolenate lines for population 1 at three environments in 2009.

Line	Environment						Overall Mean	Rank
	Conrad		Dallas Center		Denison			
	Mean	Rank	Mean	Rank	Mean	Rank		
	g kg^{-1}		g kg^{-1}		g kg^{-1}		g kg^{-1}	
7	769	10	775	13	775	9	773	11
8	769	9	776	11	774	10	773	10
9	794	1	802	2	798	2	798	2
10	778	4	784	8	781	5	781	5
11	698	14	788	5	738	14	741	14
12	775	7	779	9	778	7	777	7
13	777	5	789	4	775	8	782	4
14	749	12	786	6	778	6	771	12
15	776	6	772	14	770	12	773	9
16	770	8	777	10	773	11	773	8
17	790	2	804	1	801	1	798	1
18	732	13	775	12	749	13	752	13
19	779	3	785	7	784	4	783	3
20	760	11	790	3	789	3	780	6

Table 7. Rank correlation coefficients for oleate concentration of high-oleate/low-linolenate soybean lines from population 1 at three environments in 2009.

	Environment	
Environment	Dallas Center	Denison
Conrad	0.34 ns†	0.65 **
Dallas Center		0.69 **

** Significant at the 0.01 probability level
†ns = not significant at the 0.05 probability level

Table 8. Phenotypic correlation coefficients for oleate concentration of high-oleate/low-linolenate soybean lines from population 1 at three environments in 2009.

	Environment	
Environment	Dallas Center	Denison
Conrad	0.24 ns†	0.87 **
Dallas Center		0.56 *

* Significant at the 0.05 probability level
** Significant at the 0.01 probability level
†ns = not significant at the 0.05 probability level

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APPENDIX A

ANALYSES OF VARIANCE AND ENTRY MEANS FOR AGRONOMIC AND SEED TRAITS ACROSS ENVIRONMENTS

Table A1. Analysis of variance for yield of four populations across three Iowa, one Ohio, and one Illinois environment in 2009.

	Mean Squares											
	Population 1			Population 2			Population 3			Population 4		
Sources of Variation†	df	Yield (kg ha^{-1})		df	Yield (kg ha^{-1})		df	Yield (kg ha^{-1})		df	Yield (kg ha^{-1})	
Environment	4	6437722	**	4	7411601	**	4	5379698	**	4	6272873	**
Rep/Environment	5	300284	**	5	76469	ns‡	4	407089	**	5	204081	**
Genotype	41	592792	**	47	524343	**	50	437983	**	71	527709	**
HOLL	13	1139601	**	15	863774	**	16	514292	**	23	617793	**
HONL	13	139866	ns	15	266918	**	16	478870	**	23	450875	**
NONL	13	399538	**	15	315952	**	16	250260	**	23	360039	**
Class	2	1252956	**	2	1541073	**	2	1073797	*	2	2233416	**
Genotype x Environment	164	121805	*	188	110674	**	200	120977	**	284	120648	**
HOLL x Environment	52	142014	**	60	139233	ns	64	95397	*	92	127551	**
HONL x Environment	52	135903	ns	60	120742	**	64	141976	*	92	111660	*
NONL x Environment	52	81025	**	60	61273	ns	64	116298	*	92	120348	**
Class x Environment	8	161361	*	8	189344	ns	8	195067	ns	8	139993	ns
Error	203	96084		234	80048		200	76808		340	73667	
HOLL Error	64	83896		75	99617		64	63235		115	76884	
HONL Error	65	100379		75	70761		64	90038		103	78385	
NONL Error	64	112443		74	70914		64	75986		112	63015	
Class Error	10	41639		10	69453		8	86132		10	125034	
CV (%)¶		7.9			7.0			7.1			6.9	

*Significant at $p \leq 0.05$.

** Significant at $p \leq 0.01$.

†HOLL = high-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines.

‡ns = Not significant at the 0.05 probability level.

§ = Coefficient of variation

Table A2. Analysis of variance for population 1 across three Iowa environments in 2009.

		Mean Squares													
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})	
Environment	2	5404.7	ns‡	225.5	ns	294.1	**	428.8	*	3925.2	ns	2208.7	ns	336.2	ns
Rep/Environment	3	1704.5	ns	42.7	**	11.6	ns	24.8	**	1233.3	ns	296.7	**	89.8	**
Genotype	41	412856.8	**	3062.4	**	1787.0	**	54.9	**	312822.6	**	300.7	**	121.3	**
HOLL	13	1344.6	**	11.0	*	48.6	**	61.8	**	903.8	**	172.3	**	80.7	**
HONL	13	3935.0	**	76.0	**	76.7	**	51.7	**	3000.0	**	324.8	**	118.1	**
NONL	13	1067.4	*	880.4	**	121.2	**	49.6	**	1879.3	**	360.6	**	101.4	**
Class	2	8468048.6	**	56840.5	**	35258.1	**	69.2	**	6408013.6	**	625.6	**	536.4	**
Genotype x Environment	82	528.7	ns	8.7	ns	7.3	ns	7.7	*	444.8	ns	26.7	**	8.8	**
HOLL x Environment	26	318.6	ns	5.2	ns	2.5	ns	10.3	*	276.4	ns	20.4	ns	8.9	*
HONL x Environment	26	762.2	ns	9.1	ns	8.9	ns	6.1	ns	606.5	ns	31.3	*	5.5	ns
NONL x Environment	26	502.0	ns	9.9	ns	9.9	ns	7.1	ns	428.8	ns	27.7	**	9.0	**
Class x Environment	4	569.2	ns	21.1	ns	10.6	ns	5.3	ns	593.7	ns	36.6	ns	27.5	**
Error	121	677.1		9.5		6.7		5.2		497.5		16.9		4.0	
HOLL Error	38	563.3		6.8		5.1		5.5		428.7		23.9		4.7	
HONL Error	39	894.9		10.8		6.1		6.0		666.7		15.8		3.8	
NONL Error	38	552.5		10.1		8.7		4.2		398.6		10.8		3.8	
Class Error	6	802.9		16.1		7.0		4.8		485.8		14.5		2.8	
CV (%)¶		4.4		6.0		3.1		5.2		9.7		1.2		1.1	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table A2. Continued

Sources of Variation	df	Mean Squares: Seed Wt. (mg seed^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Environment	2	216.8	ns	2	565.9	**	11316.6	**	4.8	ns
Rep/Environment	3	140.9	**	3	23.0	**	255.8	**	0.9	**
Genotype	41	689.3	**	41	54.5	**	177.0	**	2.0	**
HOLL	13	559.0	**	13	46.1	**	167.4	**	1.6	**
HONL	13	962.7	**	13	67.3	**	225.5	**	2.6	**
NONL	13	494.0	**	13	50.3	**	135.2	**	1.8	**
Class	2	747.6	**	2	52.0	*	194.9	ns	2.7	**
Genotype x Environment	82	61.9	**	82	3.7	**	29.1	**	0.3	*
HOLL x Environment	26	67.4	**	26	3.6	*	20.5	ns	0.2	ns
HONL x Environment	26	81.3	**	26	2.7	ns	35.6	ns	0.4	ns
NONL x Environment	26	40.6	ns	26	4.4	**	28.4	*	0.3	ns
Class x Environment	4	43.7	ns	4	6.0	ns	47.0	ns	0.1	ns
Error	121	21.8		123	2.0		18.6		0.2	
HOLL Error	38	13.4		39	1.9		16.8		0.2	
HONL Error	39	23.1		39	2.3		23.0		0.2	
NONL Error	38	29.3		39	1.5		15.1		0.2	
Class Error	6	20.9		6	3.1		24.7		0.2	
CV (%)		2.6			5.2		4.3		20.0	

Table A3. Analysis of variance for population 2 across three Iowa environments in 2009.

		Mean Squares															
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})	
Environment	2	2606.5	*	182.7	*	408.0	**	635.2	**	1883.2	**	161.6	*	332.6	*
Rep/Environment	3	152.8	ns‡	10.3	ns	0.5	ns	15.8	**	71.2	ns	12.5	ns	21.5	**
Genotype	47	425093.1	**	2874.6	**	1529.1	**	73.6	**	324010.0	**	197.9	**	98.3	**
HOLL	15	863.4	ns	17.2	**	64.5	**	38.5	**	699.0	ns	146.3	**	67.4	**
HONL	15	4475.8	**	121.1	**	63.4	**	33.8	**	4093.6	**	196.2	**	98.0	**
NONL	15	2333.5	**	467.2	**	82.6	**	66.7	**	3096.9	**	130.2	**	36.6	**
Class	2	9942379.7	**	63296.3	**	34370.8	**	685.9	**	7561107.2	**	792.5	**	792.5	**
Genotype x Environment	94	645.1	ns	9.7	ns	4.9	ns	5.1	ns	508.3	ns	17.8	**	6.6	**
HOLL x Environment	30	632.4	ns	4.2	ns	3.9	ns	3.7	ns	489.3	ns	18.0	ns	4.7	ns
HONL x Environment	30	554.8	ns	7.4	ns	2.9	ns	6.5	ns	432.2	ns	14.1	*	7.3	**
NONL x Environment	30	667.1	ns	12.6	ns	6.4	ns	5.3	ns	538.5	*	11.8	**	7.8	**
Class x Environment	4	1204.4	ns	47.7	**	15.5	ns	3.5	ns	946.4	ns	6.4	ns	6.4	ns
Error	139	594.0		7.5		5.0		4.3		472.1		8.1		3.2	
HOLL Error	43	578.6		5.6		4.9		3.3		425.4		11.2		4.5	
HONL Error	45	817.5		7.8		4.7		5.3		688.5		7.8		2.5	
NONL Error	45	410.5		9.3		4.8		4.6		310.6		5.6		2.5	
Class Error	6	437.7		4.4		8.9		3.5		429.1		4.7		4.7	
CV (%)¶		4.1		5.3		2.9		4.8		9.4		0.8		1.0	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table A3. Continued

Sources of Variation	df	Mean Squares: Seed Wt. (mg seed^{-1})		df	Maturity (days#)		Height (cm)		Lodging (score ††)	
Environment	2	5414.9	**	2	163.2	**	9915.1	**	5.8	**
Rep/Environment	3	14.7	ns	3	4.6	ns	121.8	**	0.1	ns
Genotype	47	372.1	**	47	22.4	**	129.2	**	0.2	**
HOLL	15	420.8	**	15	20.8	**	144.3	**	0.3	**
HONL	15	262.9	**	15	25.6	**	64.9	**	0.2	ns
NONL	15	336.9	**	15	21.0	**	195.5	**	0.1	ns
Class	2	1110.3	**	2	21.2	**	0.2	ns	0.8	ns
Genotype x Environment	94	42.2	**	94	2.8	**	14.2	ns	0.1	**
HOLL x Environment	30	30.7	**	30	4.0	ns	8.6	ns	0.1	ns
HONL x Environment	30	36.5	**	30	2.4	ns	17.5	ns	0.1	**
NONL x Environment	30	57.8	**	30	2.3	*	17.2	ns	0.1	ns
Class x Environment	4	51.2	ns	4	1.4	ns	9.2	ns	0.2	*
Error	139	15.1		141	1.9		15.6		0.0	
HOLL Error	43	12.2		45	2.4		12.8		0.0	
HONL Error	45	13.7		45	2.1		10.9		0.0	
NONL Error	45	19.5		45	1.3		23.4		0.1	
Class Error	6	15.2		6	0.8		12.8		0.0	
CV (%)		2.2			5.1		4.4		13.6	

Table A4. Analysis of variance for population 3 across three Iowa environments in 2009.

		Mean Squares													
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})	
Environment	2	1132.1	ns‡	60.5	**	187.5	ns	452.8	**	758.0	ns	1508.8	ns	582.7	ns
Rep/Environment	2	664.2	ns	0.3	ns	17.8	**	4.3	ns	480.6	ns	403.1	**	66.7	**
Genotype	50	321345.6	**	2479.2	**	1126.7	**	59.0	**	243516.2	**	148.2	**	114.6	**
HOLL	16	652.1	ns	14.2	**	55.5	**	35.4	**	571.8	ns	83.4	ns	78.2	**
HONL	16	1495.9	*	95.2	**	18.5	**	25.9	**	1035.1	*	132.3	**	122.6	**
NONL	16	1501.4	**	334.2	**	32.9	**	94.0	**	1681.4	**	66.7	**	102.6	**
Class	2	8563846.4	**	62345.6	**	29359.1	**	247.6	**	6481078.3	**	1648.4	*	457.2	**
Genotype x Environment	98	526.7	ns	16.1	**	5.3	ns	5.1	*	376.6	ns	32.4	**	6.4	*
HOLL x Environment	31	581.6	ns	4.6	ns	4.1	ns	3.5	ns	429.5	ns	44.1	*	7.9	ns
HONL x Environment	31	655.2	**	10.2	ns	4.6	**	4.6	ns	500.6	**	15.8	ns	4.0	ns
NONL x Environment	32	320.8	ns	23.4	*	7.2	ns	7.6	ns	200.1	ns	13.0	ns	7.5	*
Class x Environment	4	697.9	ns	90.3	**	6.5	ns	1.9	ns	387.2	ns	221.1	**	7.3	ns
Error	100	506.8		9.1		4.2		3.6		385.2		19.1		4.4	
HOLL Error	32	529.8		6.4		3.0		3.1		369.5		24.0		4.6	
HONL Error	32	99.5		8.5		2.1		3.1		58.1		16.1		4.8	
NONL Error	32	905.1		13.1		6.6		4.6		739.2		18.7		4.1	
Class Error	4	393.0		4.1		10.2		2.7		294.2		6.8		2.5	
CV (%)¶		3.7		5.8		2.7		4.5		8.7		1.2		1.2	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table A4. Continued

		Mean Squares								
Sources of Variation	df	Seed Wt. (mg seed^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Environment	2	9235.9	**	2	100.3	ns	6982.4	*	15.6	**
Rep/Environment	2	145.0	**	2	20.4	**	186.8	**	0.2	ns
Genotype	50	357.4	**	50	22.9	**	138.1	**	0.5	**
HOLL	16	518.4	**	16	20.7	**	188.3	**	0.4	**
HONL	16	215.7	**	16	22.2	**	151.4	**	0.6	**
NONL	16	302.1	**	16	27.9	**	80.4	**	0.5	**
Class	2	658.6	*	2	6.2	ns	103.2	ns	0.1	ns
Genotype x Environment	98	28.8	ns	100	2.4	ns	16.6	ns	0.1	*
HOLL x Environment	31	27.9	ns	32	2.9	ns	16.5	ns	0.1	*
HONL x Environment	31	14.6	ns	32	2.3	ns	17.8	ns	0.1	ns
NONL x Environment	32	37.5	ns	32	1.8	ns	14.6	ns	0.1	ns
Class x Environment	4	71.3	*	4	4.7	ns	24.1	ns	0.0	ns
Error	100	23.7		100	2.2		13.9		0.1	
HOLL Error	32	17.9		32	2.4		19.6		0.0	
HONL Error	32	32.4		32	1.8		10.2		0.1	
NONL Error	32	22.9		32	1.8		10.9		0.1	
Class Error	4	7.6		4	5.6		22.9		0.1	
CV (%)		2.7			5.5		4.0		17.0	

Table A5. Analysis of variance for population 4 across three Iowa environments in 2009.

		Mean Squares															
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})	
Environment	2	191.0	ns‡	92.9	**	197.1	**	470.9	**	80.7	ns	3150.4	**	1073.6	**
Rep/Environment	3	1050.7	ns	4.7	ns	10.3	*	3.4	ns	844.0	ns	52.9	*	20.5	**
Genotype	71	419977.4	**	2650.6	**	1310.8	**	84.3	**	329436.2	**	166.7	**	119.0	**
HOLL	23	1698.7	**	14.9	**	41.9	**	81.3	**	1143.4	**	150.3	**	68.9	**
HONL	23	1723.1	**	95.1	**	69.5	**	59.7	**	929.0	**	95.6	**	83.2	**
NONL	23	2051.9	**	424.5	**	53.8	**	84.0	**	2792.5	**	141.1	**	81.0	**
Class	2	14927337.7	**	88564.2	**	44900.4	**	408.8	**	11697562.0	**	1565.1	**	1565.1	**
Genotype x Environment	142	438.9	ns	7.1	ns	4.0	ns	5.6	ns	349.8	ns	26.8	**	7.4	**
HOLL x Environment	46	402.4	ns	4.4	ns	3.0	ns	6.1	ns	295.9	ns	25.1	ns	7.8	**
HONL x Environment	46	447.8	ns	9.2	ns	2.8	ns	4.2	ns	360.6	ns	23.3	*	6.7	**
NONL x Environment	46	427.6	ns	5.9	ns	5.7	ns	5.7	ns	363.5	ns	19.7	*	7.7	**
Class x Environment	4	857.5	*	34.0	*	11.5	*	13.8	ns	694.6	ns	7.7	ns	7.7	ns
Error	207	491.8		6.0		3.7		5.6		406.6		16.5		3.8	
HOLL Error	68	422.3		5.2		3.0		5.2		324.2		22.1		4.4	
HONL Error	66	495.2		6.1		3.2		5.2		429.7		14.2		2.7	
NONL Error	67	578.4		6.5		4.9		6.7		481.2		12.8		4.4	
Class Error	6	177.5		8.1		1.7		3.9		170.0		1.9		1.9	
CV (%)¶		3.7		4.8		2.6		5.5		8.8		1.1		1.1	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

= Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table A5. Continued

Sources of Variation	df	Mean Squares: Seed Wt. (mg seed^{-1})		df	Maturity (days#)		Height (cm)		Lodging (score ††)	
Environment	2	18354.4	**	2	707.9	**	12583.7	**	14.4	*
Rep/Environment	3	20.7	ns	3	9.2	**	359.8	**	1.4	**
Genotype	71	518.9	**	71	23.6	**	142.1	**	0.4	**
HOLL	23	601.7	**	23	14.1	**	85.6	**	0.4	**
HONL	23	287.8	**	23	26.2	**	186.4	**	0.3	**
NONL	23	607.9	**	23	29.1	**	126.8	**	0.5	**
Class	2	1212.1	ns	2	40.2	**	450.2	**	40.2	**
Genotype x Environment	142	35.4	**	142	2.3	**	14.8	ns	0.1	**
HOLL x Environment	46	34.5	ns	46	1.7	**	17.0	ns	0.1	ns
HONL x Environment	46	22.2	ns	46	2.5	**	10.9	ns	0.1	ns
NONL x Environment	46	33.3	*	46	2.8	**	15.8	ns	0.2	*
Class x Environment	4	254.6	**	4	2.0	ns	22.1	ns	2.0	ns
Error	207	24.7		210	1.2		16.3		0.1	
HOLL Error	68	32.4		69	0.9		15.2		0.1	
HONL Error	66	20.5		66	1.1		16.4		0.1	
NONL Error	67	21.9		69	1.4		17.7		0.1	
Class Error	6	15.4		6	1.8		14.4		1.8	
CV (%)		2.6			4.0		4.4		17.8	

Table A6. Mean performance of 14 high-oleate/low-linolenate, 14 high-oleate/normal-linolenate, and 14 normal-oleate/normal-linolenate lines from population 1 grown in three Iowa, one Ohio, and one Illinois environments in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	773	27	73	45	82	4264	28	102	2.7	358	172	195
8	HOLL	773	24	67	45	91	3950	31	105	2.9	350	176	196
9	HOLL	798	21	66	42	73	3911	29	100	1.7	348	186	172
10	HOLL	781	23	68	47	81	3760	30	97	2.3	353	183	169
11	HOLL	741	24	71	46	118	3297	28	92	1.8	355	178	162
12	HOLL	777	23	72	52	76	3092	28	93	2.0	353	177	178
13	HOLL	782	25	68	44	81	3833	26	102	2.0	350	179	185
14	HOLL	771	23	76	44	86	3715	22	91	2.0	362	177	179
15	HOLL	773	24	72	45	86	4237	32	108	3.1	363	174	181
16	HOLL	773	25	72	45	85	4198	26	100	1.5	359	174	172
17	HOLL	798	23	70	43	66	4074	23	96	1.5	364	179	190
18	HOLL	752	25	74	50	99	3833	29	102	1.8	348	175	171
19	HOLL	783	23	72	43	79	4102	29	106	1.7	354	179	173
20	HOLL	780	24	73	40	83	3966	27	101	1.6	356	178	174
21	HONL	760	58	69	41	72	3873	28	101	3.0	372	175	192
22	HONL	738	62	74	42	84	3948	25	102	1.9	356	175	173
23	HONL	777	50	70	41	62	3732	27	106	2.8	350	185	181
24	HONL	749	55	79	49	68	3889	26	101	1.8	357	179	178
25	HONL	786	58	65	45	46	4035	25	104	2.1	369	171	180
26	HONL	800	53	67	37	43	4062	21	90	1.7	360	177	184
27	HONL	732	50	71	42	105	3936	29	100	1.8	347	178	185
28	HONL	793	55	66	47	39	3872	30	110	3.2	363	176	218
29	HONL	789	52	68	45	46	3748	25	106	2.7	360	184	199

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table A6. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	732	58	71	43	96	3964	30	104	2.5	351	174	167
31	HONL	786	56	71	43	44	4040	22	91	1.3	359	183	174
32	HONL	801	52	65	43	39	4013	31	109	2.7	347	183	177
33	HONL	796	51	69	41	43	3688	27	103	2.4	356	185	185
34	HONL	780	55	71	44	50	3919	32	111	3.6	361	177	176
35	NONL	224	43	106	42	585	4020	24	96	1.6	353	188	186
36	NONL	212	87	116	46	539	3786	20	93	1.8	356	179	175
37	NONL	207	72	111	45	565	4034	23	100	2.5	346	185	169
38	NONL	211	71	108	46	564	3724	27	100	2.3	348	183	172
39	NONL	206	76	109	47	562	3743	23	94	2.0	341	191	190
40	NONL	211	82	100	45	562	3962	30	107	2.1	359	175	178
41	NONL	217	67	108	51	557	4306	28	108	2.9	347	183	172
42	NONL	212	72	104	48	564	4135	30	103	1.8	347	178	190
43	NONL	232	71	103	41	553	4085	26	108	2.6	354	181	196
44	NONL	235	70	105	44	546	3968	30	106	3.2	342	184	182
45	NONL	247	85	105	42	521	4292	27	102	2.2	361	181	188
46	NONL	214	88	97	40	561	4222	25	102	1.8	360	182	190
47	NONL	244	88	105	43	520	4233	25	103	1.8	369	179	196
48	NONL	223	86	108	43	540	4283	26	101	1.1	348	188	187
SEM		9	1	1	1	9	110	1	2	0	2	1	3
LSD 0.05		26	3	3	3	24	308	2	6	1	6	4	9
LSD 0.01		35	5	4	4	34	407	3	8	1	8	5	12
92M61		208	85	101	37	569	4205	23	101	1.7	336	193	155
92Y80		220	85	107	48	540	4001	25	98	1.3	358	186	173
93M11		231	77	99	52	541	4104	27	94	1.0	338	197	161
93M42		232	80	104	60	524	4028	32	109	2.3	349	170	162
92Y80#		211	87	108	45	549	4201	24	97	1.3	360	187	173
92Y30		224	84	101	41	550	3748	19	90	1.4	339	193	148

Table A7. Mean performance of 16 high-oleate/low-linolenate, 16 high-oleate/normal-linolenate, and 16 normal-oleate/normal-linolenate lines from population 2 grown in three Iowa, one Ohio, and one Illinois environments in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	771	23	64	41	101	3778	27	88	1.5	348	172	168
8	HOLL	780	25	67	44	84	4085	31	97	1.4	349	168	180
9	HOLL	797	24	62	45	72	2981	26	88	1.4	357	176	155
10	HOLL	807	24	65	42	62	4096	29	86	1.8	353	178	172
11	HOLL	776	24	68	43	89	3948	24	91	1.9	359	177	168
12	HOLL	786	24	70	40	80	4329	28	98	1.9	359	175	174
13	HOLL	794	24	61	39	82	3915	26	90	1.5	358	168	171
14	HOLL	799	23	66	40	72	3938	28	85	1.7	351	174	165
15	HOLL	768	26	66	38	102	3991	26	89	2.0	361	172	175
16	HOLL	791	20	69	35	85	3748	26	80	1.5	360	171	153
17	HOLL	771	25	70	41	93	4111	30	91	1.7	355	172	170
18	HOLL	783	21	65	41	90	3976	31	90	1.6	367	169	186
19	HOLL	804	25	60	40	71	4144	27	88	1.7	359	167	173
20	HOLL	772	25	70	41	92	3829	30	85	1.7	354	170	179
21	HOLL	780	26	71	41	82	4036	28	96	2.1	363	173	168
22	HOLL	787	22	68	45	78	4081	28	95	1.9	359	174	179
23	HONL	791	51	64	44	50	3644	28	81	1.3	360	168	186
24	HONL	797	58	66	41	38	3981	26	93	1.6	351	173	180
25	HONL	791	60	67	40	42	4001	25	91	1.6	358	171	186
26	HONL	782	55	68	43	52	3946	28	91	1.8	363	171	181
27	HONL	693	51	68	44	144	4099	30	93	1.8	358	171	175
28	HONL	793	52	67	42	46	3707	25	90	1.8	371	169	172
29	HONL	787	57	63	49	44	4160	31	92	1.8	358	168	182

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.

‡ = Days after 31 August.

§ = Score 1 (all plants erect) to 5 (all plants prostrate).

¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

= Seed source is different from all other entries

Table A7. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	780	53	70	44	53	3796	30	88	1.7	360	170	174
31	HONL	790	52	65	43	50	4192	26	91	1.6	353	172	186
32	HONL	792	59	61	41	47	3874	27	92	1.8	355	168	166
33	HONL	807	53	67	39	34	4023	25	84	1.5	351	177	171
34	HONL	760	67	69	42	62	4031	25	91	1.7	365	174	169
35	HONL	791	59	70	40	40	4151	25	88	1.5	353	182	170
36	HONL	808	56	61	40	35	3981	25	89	1.6	364	172	176
37	HONL	770	50	62	45	73	4124	26	94	1.7	355	175	172
38	HONL	757	61	71	42	69	4128	26	88	1.3	352	178	169
39	NONL	225	70	98	48	559	3987	25	92	1.8	349	179	170
40	NONL	286	85	100	41	488	4143	26	80	1.4	357	177	179
41	NONL	233	84	97	50	536	4104	26	90	1.3	347	181	170
42	NONL	216	81	99	45	559	4387	26	96	1.5	344	180	186
43	NONL	210	67	103	43	577	4028	26	85	1.5	358	177	184
44	NONL	226	64	101	45	564	3929	24	93	1.5	352	176	176
45	NONL	215	71	105	43	566	3995	25	83	1.4	359	178	184
46	NONL	225	67	94	48	566	4184	28	96	1.4	354	175	174
47	NONL	202	70	98	45	585	4416	32	91	1.7	346	180	193
48	NONL	236	85	95	55	529	4204	30	94	1.7	352	173	174
49	NONL	213	68	105	48	566	3940	26	84	1.3	357	175	169
50	NONL	215	73	100	44	568	3941	26	80	1.5	352	177	188
51	NONL	219	88	93	48	552	4354	27	95	1.4	351	175	168
52	NONL	214	74	99	46	567	4396	29	95	1.8	348	179	181
53	NONL	212	88	104	44	552	4183	26	92	1.6	345	182	174
54	NONL	245	63	95	47	550	3870	27	89	1.4	355	177	173
SEM		10	1	1	1	9	105	1	2	0	2	1	3
LSD 0.05		31	4	3	3	26	302	2	4	0	5	3	7
LSD 0.01		40	5	3	3	34	398	3	6	0	6	4	10

Table A7. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
92M61		214	84	98	37	567	4207	27	86	1.8	340	193	159
92Y80		286	81	100	48	485	4089	25	85	1.5	364	186	177
93M11		226	80	98	49	547	4005	26	81	1.0	345	196	163
93M42		238	83	103	53	523	4029	31	100	1.6	356	167	167
93M11#		239	77	98	49	537	4205	27	83	1.0	344	196	164
93Y11		230	82	100	42	546	3963	26	85	1.2	358	184	182

Table A8. Mean performance of 17 high-oleate/low-linolenate, 17 high-oleate/normal-linolenate, and 17 normal-oleate/normal-linolenate lines from population 3 grown in three Iowa, one Ohio, and one Illinois environments in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	805	21	64	45	65	3886	25	90	1.5	355	181	180
8	HOLL	788	23	64	44	81	3630	27	85	1.7	356	172	170
9	HOLL	780	21	69	46	84	4107	29	95	1.7	361	174	192
10	HOLL	785	24	67	42	82	3611	26	80	1.4	360	183	175
11	HOLL	774	22	73	40	91	3933	25	91	1.5	361	179	187
12	HOLL	806	21	65	44	64	3580	25	90	1.9	356	187	198
13	HOLL	777	21	70	41	91	3928	27	95	2.4	358	180	185
14	HOLL	789	24	70	42	75	3885	24	98	1.4	364	184	194
15	HOLL	777	26	66	40	91	3974	30	98	1.8	359	174	200
16	HOLL	796	25	69	44	66	3643	25	88	1.4	359	177	179
17	HOLL	797	23	63	46	71	4112	28	96	1.2	353	173	183
18	HOLL	781	25	63	39	92	3852	26	86	1.3	363	180	176
19	HOLL	786	21	66	38	89	4265	27	97	1.7	365	174	201
20	HOLL	797	23	62	44	74	4096	30	104	2.0	364	175	207
21	HOLL	814	19	61	45	61	3660	27	94	1.9	358	181	191
22	HOLL	790	25	67	39	79	3843	25	93	1.7	360	177	183
23	HOLL	789	22	70	46	73	3271	23	81	1.4	372	177	170
24	HONL	791	57	67	42	43	4073	25	96	1.2	357	178	185
25	HONL	791	58	61	42	48	4100	31	98	1.9	368	169	197
26	HONL	800	54	65	37	44	4029	25	87	1.5	373	178	188
27	HONL	798	60	59	41	42	3992	29	96	1.8	362	170	185
28	HONL	773	63	65	35	64	3852	28	90	1.7	364	183	167
29	HONL	808	57	63	38	34	3995	26	93	1.2	372	174	184

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.

‡ = Days after 31 August.

§ = Score 1 (all plants erect) to 5 (all plants prostrate).

¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

= Seed source is different from all other entries

Table A8. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	805	57	63	41	34	4113	26	99	1.8	356	180	179
31	HONL	808	55	63	41	33	4042	27	95	1.7	358	184	173
32	HONL	802	54	61	40	43	3827	28	94	1.9	360	183	182
33	HONL	802	55	61	39	43	4019	26	85	1.4	360	183	190
34	HONL	793	54	64	38	51	3212	25	81	1.8	371	173	183
35	HONL	783	52	65	40	60	3660	29	89	1.7	357	173	183
36	HONL	782	52	63	41	62	3568	31	106	2.7	359	176	188
37	HONL	804	51	63	41	41	3983	25	96	1.5	360	180	194
38	HONL	790	48	65	45	52	4243	26	91	1.3	366	179	185
39	HONL	813	48	62	42	35	4074	26	92	1.7	362	181	180
40	HONL	755	65	65	39	76	3958	27	101	1.4	362	169	178
41	NONL	220	87	101	43	549	3869	27	90	1.6	352	185	178
42	NONL	214	78	99	40	569	4218	25	93	1.5	345	191	185
43	NONL	260	77	97	54	512	3815	29	91	1.6	356	180	169
44	NONL	234	84	102	50	530	3661	31	99	2.1	360	178	187
45	NONL	220	76	95	43	566	4136	26	93	1.8	360	176	195
46	NONL	211	81	99	42	567	4072	25	93	1.4	349	185	177
47	NONL	216	93	93	43	555	4229	32	92	2.4	347	175	164
48	NONL	237	66	100	46	551	4070	24	88	1.0	358	184	188
49	NONL	208	90	100	37	565	4051	24	94	1.7	352	186	177
50	NONL	228	71	97	46	558	3764	26	96	2.0	355	178	187
51	NONL	229	68	97	37	569	4022	24	88	1.6	355	183	184
52	NONL	244	75	97	45	539	4044	28	98	1.7	354	174	169
53	NONL	212	68	103	44	573	4187	27	93	1.5	356	182	176
54	NONL	225	87	95	42	551	3744	30	105	1.7	353	183	184
55	NONL	253	83	95	48	521	4044	28	96	1.4	356	183	181
56	NONL	272	74	96	41	517	4193	28	91	2.0	356	177	182
57	NONL	243	67	96	41	553	4060	26	95	1.6	353	187	188

Table A8. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
SEM		9	2	1	1	8	110	1	2	0	2	1	2
LSD 0.05		29	5	3	3	24	323	2	5	0	7	3	7
LSD 0.01		40	7	4	4	32	426	3	7	1	9	4	9
92M61		212	86	98	37	567	4079	24	91	1.4	338	192	156
92Y80		275	78	103	43	501	4210	24	89	1.6	358	189	177
93M11		221	81	96	48	554	4160	26	88	1.0	344	194	162
93M42		240	81	104	58	517	4045	32	101	1.6	356	169	165
93Y11#		260	80	95	45	520	4048	28	88	1.3	357	184	182
93Y11		237	83	98	44	538	4069	27	88	1.1	357	183	183

Table A9. Mean performance of 24 high-oleate/low-linolenate, 24 high-oleate/normal-linolenate, and 24 normal-oleate/normal-linolenate lines from population 4 grown in three Iowa, one Ohio, and one Illinois environments in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	804	22	60	43	71	4154	29	93	1.8	358	173	203
8	HOLL	800	21	63	46	70	3165	25	89	1.8	361	178	177
9	HOLL	801	25	66	47	61	3962	28	94	1.4	349	173	191
10	HOLL	812	25	63	39	61	4096	26	86	1.3	350	182	176
11	HOLL	759	25	67	44	105	3999	27	94	2.1	363	172	192
12	HOLL	796	23	60	44	77	3915	28	90	2.1	346	178	185
13	HOLL	793	22	64	41	80	3374	26	90	2.1	358	180	179
14	HOLL	779	25	63	45	88	3685	28	91	2.1	355	176	196
15	HOLL	758	28	66	50	98	3928	29	96	2.3	355	172	190
16	HOLL	799	23	65	46	67	4199	27	93	2.0	363	173	193
17	HOLL	803	23	63	42	69	3878	30	86	1.6	355	178	170
18	HOLL	792	23	66	41	78	3907	26	85	1.9	351	180	182
19	HOLL	787	25	60	38	90	3686	26	85	1.7	346	181	173
20	HOLL	792	23	69	45	71	3755	29	98	1.7	353	176	189
21	HOLL	797	23	63	41	76	3998	25	91	2.2	353	178	177
22	HOLL	817	23	64	35	61	3782	25	89	1.6	355	180	175
23	HOLL	789	24	64	49	74	3999	28	96	1.6	359	171	192
24	HOLL	805	23	60	44	68	4203	26	89	1.6	362	175	206
25	HOLL	785	22	70	37	86	3818	24	90	1.7	357	176	198
26	HOLL	772	24	66	43	95	3499	25	95	2.0	363	178	171
27	HOLL	791	25	64	44	76	3890	27	95	1.8	358	175	183
28	HOLL	756	26	66	43	109	3932	27	93	1.8	358	175	189
29	HOLL	773	23	64	47	93	3846	28	93	1.5	353	172	189

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table A9. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HOLL	808	22	63	39	68	4042	25	85	1.5	351	183	174
31	HONL	797	61	62	39	41	3919	26	86	1.3	354	177	185
32	HONL	799	52	61	45	43	4058	30	102	2.1	354	176	202
33	HONL	805	56	59	44	36	3448	25	85	1.6	355	181	186
34	HONL	801	56	63	38	42	4021	27	98	2.2	355	176	200
35	HONL	798	59	64	41	38	3940	28	92	1.7	354	178	189
36	HONL	773	60	68	41	58	3617	27	88	1.7	352	179	193
37	HONL	785	53	63	41	58	4002	24	83	1.8	351	185	181
38	HONL	796	59	66	44	35	4109	29	97	1.8	357	175	191
39	HONL	783	58	69	42	48	3601	26	85	1.5	358	180	206
40	HONL	800	53	57	45	45	4395	28	99	1.7	350	178	197
41	HONL	796	50	66	40	48	4036	27	93	1.8	360	177	190
42	HONL	793	59	67	40	41	3729	24	89	1.8	360	181	183
43	HONL	786	63	63	38	50	3898	28	97	1.9	359	174	189
44	HONL	801	59	63	39	38	4014	28	85	1.6	351	179	190
45	HONL	789	53	61	41	56	4164	28	93	2.0	364	170	190
46	HONL	781	62	67	38	52	3464	23	90	1.9	354	179	184
47	HONL	787	55	64	47	47	3943	32	99	2.3	362	170	200
48	HONL	772	63	69	44	52	4029	27	92	1.8	363	174	195
49	HONL	792	58	66	37	47	4119	28	94	1.8	356	176	195
50	HONL	782	65	60	45	48	3943	29	92	1.9	356	175	192
51	HONL	809	53	64	39	35	3853	25	83	1.7	359	182	192
52	HONL	728	61	70	49	92	3866	28	96	1.7	362	171	178
53	HONL	756	61	67	44	72	4223	32	103	2.0	364	170	203
54	HONL	775	52	69	42	62	4028	28	92	1.3	356	178	189
55	NONL	227	67	101	47	558	4135	26	91	1.7	351	184	197
56	NONL	218	67	95	43	577	3755	29	102	2.0	349	183	180
57	NONL	268	70	96	51	515	4114	27	90	1.8	355	179	191
58	NONL	241	43	96	41	579	3802	28	89	1.4	345	183	191
59	NONL	218	72	94	43	573	4312	27	91	1.8	352	180	193

Table A9. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
60	NONL	223	69	92	42	574	3541	25	88	1.8	342	187	180
61	NONL	211	83	101	41	564	3853	28	99	1.7	349	181	180
62	NONL	206	69	92	38	595	4244	29	99	2.1	355	179	186
63	NONL	224	68	93	50	565	4061	33	101	2.8	346	181	202
64	NONL	242	74	94	43	547	3853	28	86	1.9	355	187	183
65	NONL	235	77	98	45	545	4241	28	99	1.9	351	182	205
66	NONL	221	84	100	43	552	4035	25	94	1.8	355	182	201
67	NONL	235	73	94	51	547	4227	29	95	1.7	353	177	196
68	NONL	217	84	95	44	560	4193	28	94	1.8	352	185	202
69	NONL	216	76	95	43	570	4140	27	99	2.0	360	177	193
70	NONL	213	68	91	47	581	3985	29	97	2.1	349	185	169
71	NONL	223	83	94	48	552	4114	26	95	1.8	351	186	199
72	NONL	210	66	91	40	593	4113	26	92	1.3	345	188	175
73	NONL	264	71	92	46	527	4170	28	93	1.6	350	180	198
74	NONL	217	68	97	48	570	4170	27	93	1.6	353	182	193
75	NONL	275	71	94	54	506	4090	29	100	2.0	356	175	201
76	NONL	212	74	96	46	572	3860	25	87	1.8	345	188	174
77	NONL	222	76	101	44	557	4065	34	96	1.9	356	178	184
78	NONL	217	82	93	45	563	4178	27	99	1.7	340	187	182
SEM		9	1	1	1	8	110	1	2	0	2	1	2
LSD 0.05		24	3	2	3	21	306	2	5	0	7	3	7
LSD 0.01		32	4	3	4	28	403	3	7	1	8	4	11
92M61		232	81	97	37	553	4053	26	84	1.5	338	194	156
92Y80		218	87	108	43	544	3860	28	85	1.5	359	188	178
93M11		225	78	97	46	554	4030	27	82	1.1	343	196	162
93M42		254	79	103	57	507	3952	34	98	1.7	355	168	163
93Y20#		210	85	93	38	574	4277	28	93	1.5	339	188	174
93M61		217	85	98	40	560	4012	33	89	1.4	343	181	170

APPENDIX B

ANALYSES OF VARIANCE FOR AGRONOMIC AND SEED TRAITS AT INDIVIDUAL ENVIRONMENTS

Table B1. Analysis of variance for population 1 at Conrad, IA, in 2009.

		Mean Squares															
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})		Seed Wt. (mg seed^{-1})	
Replication	1	215.7	ns	50.0	*	14.5	ns	8.6	ns	34.9	ns	348.3	**	29.3	**	249.4	**
Genotype	41	134150.7	**	1082.6	**	558.7	**	20.4	**	101282.2	**	95.6	**	45.3	**	166.2	**
HOLL	13	1250.2	ns	4.8	ns	17.1	ns	22.4	**	976.2	ns	68.8	ns	35.7	**	120.3	**
HONL	13	3156.6	**	40.5	*	30.0	**	19.8	ns	2504.2	**	93.7	**	39.3	**	242.1	**
NONL	13	387.2	*	289.0	**	46.6	**	18.8	*	774.6	**	127.7	**	41.3	**	125.9	**
Class	2	2715084.0	**	19988.3	**	10827.9	**	20.6	ns	2045977	**	82.1	ns	170.7	**	231.2	ns
Error	40	690.9		9.1		7.0		5.5		540.8		20.9		2.8		17.0	
HOLL Error	13	1223.7		5.0		10.3		2.9		967.2		38.1		4.3		7.5	
HONL Error	13	672.4		12.4		5.4		8.2		535.8		13.2		3.0		11.0	
NONL Error	12	150.7		6.6		5.7		5.5		117.2		7.2		1.2		32.3	
Class Error	2	643.5		30.4		4.2		4.4		364.8		34.0		2.2		25.3	
CV (%)¶		4.5		5.7		3.2		5.4		9.9		1.3		0.9		2.3	

		Mean Squares									
Sources of Variation	df	Yield (kg ha^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	476743.2	**	1	29.8	**	267.9	**	1.0	**
Genotype	41	235390.0	**	41	12.1	**	74.8	**	0.9	**
HOLL	13	357542.9	**	13	7.4	**	73.1	*	0.6	**
HONL	13	106724.5	ns	13	16.4	**	85.5	*	1.2	**
NONL	13	217652.2	*	13	13.6	**	58.4	**	0.8	**
Class	2	393017.7	ns	2	3.9	ns	123.5	**	1.4	ns
Error	41	53925.6		41	1.4		22.2		0.1	
HOLL Error	13	25642.9		13	2.1		22.6		0.1	
HONL Error	13	48840.2		13	0.9		31.0		0.1	
NONL Error	13	77385.1		13	1.2		16.1		0.2	
Class Error	2	118330.2		2	2.6		1.9		0.2	
CV (%)		5.4			4.1		5.2		16.7	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B2. Analysis of variance for population 1 at Dallas Center, IA, in 2009.

		Mean Squares																	
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})		Seed Wt. (mg seed^{-1})	
Replication	1	26.9	ns‡	21.0	ns	0.1	ns	61.7	**	62.6	ns	525.0	**	240.0	**	93.2	**
Genotype	41	143737.8	**	1001.2	**	621.3	**	31.2	**	109593.5	**	138.4	**	56.1	**	232.0	**
HOLL	13	189.9	**	7.5	ns	16.9	**	38.3	**	112.4	**	83.1	**	28.7	**	183.1	**
HONL	13	469.8	ns	20.9	ns	18.9	**	27.9	**	419.1	ns	174.8	**	45.8	**	332.1	**
NONL	13	802.6	ns	314.5	**	47.8	**	28.0	**	833.2	*	129.0	**	48.6	**	188.4	**
Class	2	2937118.9	**	18295.7	**	12193.4	**	27.5	**	2237796.3	**	321.9	**	350.5	**	182.3	ns
Error	41	355.1		7.9		4.9		5.0		262.8		18.2		7.1		13.7	
HOLL Error	13	38.6		3.2		1.8		8.9		16.5		18.7		8.0		7.7	
HONL Error	13	609.6		10.6		3.0		3.0		480.5		19.9		5.9		20.5	
NONL Error	13	466.7		11.0		10.8		3.9		328.4		18.2		7.6		12.5	
Class Error	2	32.2		0.7		16.5		0.0		22.8		4.8		6.1		16.7	
CV (%)¶		3.2		5.6		2.8		4.8		7.2		1.2		1.5		2.1	

		Mean Squares							
Sources of Variation	df	Yield (kg ha^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	2153.1	ns	1	21.0	**	394.3	**	0.3	ns
Genotype	41	151343.2	**	41	22.1	**	88.4	**	0.7	**
HOLL	13	188951.7	**	13	21.9	**	58.1	**	0.6	**
HONL	13	88430.6	*	13	24.6	**	125.1	**	1.0	*
NONL	13	191790.1	*	13	19.4	**	95.6	**	0.4	*
Class	2	52915.8	ns	2	24.7	ns	0.3	ns	0.7	*
Error	41	40247.5		41	1.7		16.9		0.2	
HOLL Error	13	31949.2		13	1.2		10.1		0.1	
HONL Error	13	34409.7		13	2.2		28.2		0.3	
NONL Error	13	59682.5		13	1.4		13.1		0.2	
Class Error	2	5805.2		2	3.3		11.8		0.0	
CV (%)		5.0			5.4		4.1		22.4	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B3. Analysis of variance for population 1 at Denison, IA, in 2009.

		Mean Squares																	
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})		Seed Wt. (mg seed^{-1})	
Replication	1	4871.0	*	57.2	*	20.0	ns‡	4.2	ns	3602.3	*	16.7	ns	0.0	ns	80.0	ns
Genotype	41	138533.5	**	1013.6	**	634.4	**	18.8	**	104649.3	**	124.4	**	38.7	**	417.7	**
HOLL	13	548.6	ns	8.9	ns	20.4	**	21.0	**	372.4	ns	63.2	**	35.1	**	435.6	**
HONL	13	1833.1	ns	32.8	**	46.0	**	16.1	ns	1289.8	ns	119.0	**	44.1	**	551.0	**
NONL	13	906.7	ns	296.6	**	47.2	**	17.5	**	1139.5	ns	164.4	**	31.8	**	266.5	**
Class	2	2819797.9	**	18591.0	**	12277.6	**	31.8	ns	2127842.0	**	299.0	**	72.6	**	417.3	*
Error	40	993.4		11.6		8.1		5.2		694.8		11.4		2.0		34.9	
HOLL Error	12	416.2		12.5		3.2		4.5		292.0		14.3		1.4		25.8	
HONL Error	13	1402.7		9.5		10.1		6.9		983.8		14.3		2.6		37.8	
NONL Error	13	1009.1		12.3		9.3		3.2		728.6		6.6		2.3		43.1	
Class Error	2	1733.0		17.2		16.4		9.8		1069.9		4.6		0.1		20.7	
CV (%)¶		5.4		6.7		3.4		5.4		11.3		1.0		0.8		3.2	

		Mean Squares							
Sources of Variation	df	Yield (kg ha^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	86489.0	ns	1	18.1	**	105.2	**	1.4	**
Genotype	41	346472.5	**	41	27.7	**	71.9	**	1.0	**
HOLL	13	657636.4	**	13	24.0	**	77.2	**	0.8	*
HONL	13	156214.3	**	13	31.7	**	86.1	**	1.1	**
NONL	13	177152.3	*	13	26.1	**	38.0	ns	1.1	**
Class	2	661244.9	*	2	35.5	ns	165.2	ns	0.7	ns
Error	40	67892.3		41	2.7		16.8		0.2	
HOLL Error	12	106138.7		13	2.6		17.8		0.3	
HONL Error	13	32541.6		13	3.6		9.8		0.2	
NONL Error	13	72472.3		13	1.9		16.1		0.1	
Class Error	2	38309.7		2	3.3		60.3		0.3	
CV (%)		6.4			6.2		3.6		21.0	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B4. Analysis of variance for population 2 at Atlantic, IA, in 2009.

		Mean Squares																	
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})		Seed Wt. (mg seed^{-1})	
Replication	1	4.8	ns‡	10.0	ns	0.0	ns	0.4	ns	0.0	ns	10.0	ns	1.3	ns	12.8	ns
Genotype	47	148442.0	**	1094.1	**	543.8	**	22.9	**	112730.0	**	92.7	**	31.3	**	205.8	**
HOLL	15	499.7	**	4.9	ns	24.8	**	10.9	*	467.4	**	67.1	**	37.5	**	234.7	**
HONL	15	1845.8	**	68.0	**	21.6	**	11.3	ns	1473.7	**	61.8	**	19.4	**	168.2	**
NONL	15	133.5	ns	202.6	**	32.8	**	19.5	**	411.0	**	53.5	**	16.6	**	154.0	**
Class	2	3469793.8	**	23645.8	**	12185.1	**	225.7	**	2631514.6	**	809.3	**	184.4	**	659.6	*
Error	47	215.1		7.8		3.2		4.3		147.8		8.7		3.9		29.8	
HOLL Error	15	94.3		2.5		2.2		3.7		56.1		13.0		4.3		24.4	
HONL Error	15	358.3		10.0		2.9		5.0		248.0		5.3		3.4		27.5	
NONL Error	15	195.38		11.2		4.6		4.5		136.1		7.1		4.3		37.9	
Class Error	2	192.3		6.6		2.6		1.4		172.2		14.4		3.0		27.4	
CV (%)¶		2.5		5.3		2.2		5.1		5.2		0.8		1.1		3.0	

		Mean Squares							
Sources of Variation	df	Yield (kg ha^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	31601.9	ns	1	2.7	ns	0.0	ns	0.2	ns
Genotype	47	245705.5	**	47	7.9	**	60.1	**	0.2	**
HOLL	15	376824.4	**	15	10.5	**	62.4	**	0.2	**
HONL	15	175270.0	ns	15	7.6	**	31.7	**	0.2	**
NONL	15	104981.4	ns	15	4.9	**	93.8	**	0.1	ns
Class	2	846010.8	ns	2	12.3	*	2.6	ns	0.0	ns
Error	47	70347.7		47	1.2		11.0		0.1	
HOLL Error	15	51151.7		15	1.3		13.6		0.0	
HONL Error	15	81656.0		15	1.3		9.3		0.0	
NONL Error	15	70337.1		15	0.9		8.3		0.1	
Class Error	2	129586.0		2	0.8		25.0		0.0	
CV (%)		6.4			4.1		3.3		13.0	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B5. Analysis of variance for population 2 at Hedrick, IA, in 2009.

		Mean Squares																	
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})		Seed Wt. (mg seed^{-1})	
Replication	1	63.4	ns‡	19.7	ns	1.1	ns	29.3	**	0.7	ns	27.1	ns	58.6	**	18.4	ns
Genotype	47	139777.8	**	922.6	**	523.4	**	23.7	**	106374.5	**	77.2	**	35.7	**	102.1	**
HOLL	15	1058.5	ns	15.2	ns	25.3	**	18.9	**	824.6	ns	59.5	**	19.2	**	105.6	**
HONL	15	1498.5	ns	30.1	**	21.0	*	7.2	ns	1275.5	ns	91.9	**	35.7	**	67.2	**
NONL	15	1694.4	**	122.2	**	33.0	**	24.0	**	1967.2	**	54.6	**	16.2	**	128.7	**
Class	2	3252892.9	**	20425.8	**	11705.1	**	182.5	**	2469295.7	**	269.5	**	306.6	**	139.2	ns
Error	47	996.9		10.6		7.2		4.2		774.5		10.3		3.1		8.8	
HOLL Error	15	1075.0		11.0		8.0		3.1		752.4		13.1		5.1		7.0	
HONL Error	15	1501.5		9.6		7.6		4.7		1300.0		13.2		2.7		9.1	
NONL Error	15	475.9		12.3		4.1		5.1		308.9		5.5		1.7		9.8	
Class Error	2	533.8		2.8		20.6		2.9		491.4		4.2		2.5		12.4	
CV (%)¶		5.3		6.3		3.5		4.7		12.2		0.9		1.0		1.8	

		Mean Squares							
Sources of Variation	df	Yield (kg ha^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	12337.5	ns	1	10.0	ns	308.2	**	0.0	ns
Genotype	47	163301.3	**	47	10.0	**	44.8	**	0.1	**
HOLL	15	235794.0	*	15	10.2	**	33.9	*	0.1	ns
HONL	15	121247.5	ns	15	9.1	*	39.3	**	0.1	ns
NONL	15	135747.2	*	15	10.7	**	66.6	ns	0.1	ns
Class	2	141664.7	ns	2	9.3	ns	5.2	ns	0.6	**
Error	47	68848.0		47	2.8		21.4		0.1	
HOLL Error	15	78255.0		15	3.3		13.3		0.1	
HONL Error	15	80979.4		15	3.1		11.2		0.1	
NONL Error	15	53130.9		15	2.3		42.4		0.0	
Class Error	2	25188.4		2	1.0		0.7		0.0	
CV (%)		6.6			5.9		5.4		16.4	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B6. Analysis of variance for population 2 at Washington, IA, in 2009.

		Mean Squares																	
Sources of Variation†	df	Oleate ($g\ kg^{-1}$)		Linolenate ($g\ kg^{-1}$)		Palmitate ($g\ kg^{-1}$)		Stearate ($g\ kg^{-1}$)		Linoleate ($g\ kg^{-1}$)		Protein ($g\ kg^{-1}$ §)		Oil ($g\ kg^{-1}$)		Seed Wt. ($mg\ seed^{-1}$)	
Replication	1	390.3	ns‡	1.3	ns	0.4	ns	17.8	*	213.0	ns	0.4	ns	4.8	ns	12.9	ns
Genotype	47	138825.1	**	893.7	**	474.2	**	37.0	**	106320.6	**	63.8	**	44.6	**	152.9	**
HOLL	15	604.2	ns	5.6	ns	23.7	**	15.9	**	406.3	ns	56.8	**	20.8	**	153.0	**
HONL	15	2241.2	**	37.7	**	26.5	**	28.3	**	2208.7	**	70.6	**	57.5	**	100.6	**
NONL	15	1839.7	**	167.5	**	29.6	**	33.9	**	1795.7	**	45.7	**	19.5	**	169.9	**
Class	2	3223490.2	**	19396.6	**	10530.1	**	283.4	*	2462684.2	**	200.0	**	313.5	*	411.8	**
Error	45	569.0		3.9		4.5		4.5		494.9		5.1		2.6		6.4	
HOLL Error	13	564.4		3.1		4.3		2.9		474.2		7.1		4.1		3.9	
HONL Error	15	592.8		3.9		3.7		6.3		517.6		5.0		1.6		4.4	
NONL Error	15	559.7		4.6		5.7		4.2		486.9		4.1		1.4		10.9	
Class Error	2	586.9		3.8		3.4		6.1		623.6		0.6		8.7		5.8	
CV (%)¶		4.0		3.9		2.8		4.7		9.6		0.6		0.9		1.5	

		Mean Squares							
Sources of Variation	df	Yield ($kg\ ha^{-1}$)		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	84268.5	ns	1	1.3	ns	57.0	*	0.1	*
Genotype	47	194388.5	**	47	10.2	**	52.7	**	0.1	**
HOLL	15	375792.4	**	15	8.0	*	65.3	**	0.1	**
HONL	15	70680.0	*	15	13.7	**	28.9	*	0.1	**
NONL	15	141130.8	**	15	9.9	**	69.5	**	0.1	*
Class	2	161105.5	**	2	2.3	ns	10.8	ns	0.5	ns
Error	47	33559.2		47	1.7		14.4		0.0	
HOLL Error	15	30199.3		15	2.7		11.4		0.0	
HONL Error	15	30384.7		15	1.9		12.3		0.0	
NONL Error	15	44400.1		15	0.8		19.7		0.0	
Class Error	2	1259.6		2	0.5		12.5		0.0	
CV (%)		4.2			4.9		4.6		11.5	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 $g\ kg^{-1}$.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B7. Analysis of variance for population 3 at Atlantic, IA, in 2009.

		Mean Squares																	
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})		Seed Wt. (mg seed^{-1})	
Replication	1	280.0	ns‡	0.4	ns	8.0	ns	5.0	ns	150.7	ns	123.0	**	19.0	**	54.4	ns
Genotype	50	145938.4	**	1221.4	**	530.8	**	20.4	**	109897.6	**	121.0	**	52.2	**	204.4	**
HOLL	16	373.3	ns	3.4	ns	27.2	**	14.4	**	328.2	*	65.3	**	39.7	**	258.5	**
HONL	16	402.8	**	62.0	**	11.9	**	16.1	**	216.0	**	69.1	**	48.7	**	150.8	**
NONL	16	870.0	ns	135.3	**	21.0	**	23.5	**	714.6	ns	42.9	**	56.1	**	196.2	**
Class	2	3635291.6	**	28930.0	**	12788.7	**	78.3	*	2737369.2	**	1605.9	**	147.7	*	266.8	*
Error	50	353.0		8.5		3.6		2.7		271.0		14.1		3.0		24.9	
HOLL Error	16	189.9		1.9		2.7		2.1		125.8		15.1		3.9		6.0	
HONL Error	16	39.0		11.6		2.1		2.8		12.1		12.6		1.6		41.1	
NONL Error	16	849.2		12.3		6.3		3.0		688.5		14.5		3.3		29.9	
Class Error	2	199.8		6.1		1.6		3.7		163.4		13.2		4.3		6.6	
CV (%)¶		3.1		5.5		2.5		4.1		7.3		1.0		1.0		2.6	

		Mean Squares							
Sources of Variation	df	Yield (kg ha^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	187908.5	*	1	3.2	ns	90.4	**	0.2	ns
Genotype	50	359501.2	**	50	7.7	**	86.3	**	0.5	**
HOLL	16	275195.4	**	16	7.5	**	115.6	**	0.4	**
HONL	16	482061.4	**	16	6.2	**	101.7	**	0.5	**
NONL	16	248899.4	**	16	9.8	**	34.9	**	0.5	**
Class	2	938279.2	ns	2	4.3	*	140.3	ns	0.0	ns
Error	50	48651.6		50	1.2		14.6		0.1	
HOLL Error	16	23197.3		16	0.6		21.7		0.1	
HONL Error	16	62137.2		16	1.2		10.6		0.1	
NONL Error	16	52071.8		16	2.0		10.8		0.1	
Class Error	2	117038.6		2	0.1		19.9		0.0	
CV (%)		5.5			4.3		3.7		16.2	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B8. Analysis of variance for population 3 at Hedrick, IA, in 2009.

		Mean Squares																	
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})		Seed Wt. (mg seed^{-1})	
Replication	1	1048.3	ns‡	0.2	ns	27.5	**	3.7	ns	810.4	ns	683.3	**	114.4	**	235.5	**
Genotype	50	140773.9	**	1031.2	**	498.8	**	27.8	**	106755.1	**	86.9	**	51.1	**	173.5	**
HOLL	16	740.1	ns	18.8	ns	18.3	**	18.9	**	535.5	ns	91.1	*	36.2	**	294.7	**
HONL	16	266.3	ns	41.1	**	7.2	**	11.0	**	203.7	ns	75.3	**	60.0	**	91.4	**
NONL	16	1108.9	ns	187.8	**	17.4	*	42.2	**	1150.8	ns	47.3	ns	38.3	**	115.6	**
Class	2	3502424.4	**	23798.4	**	12126.8	**	118.4	**	2653757.3	**	464.1	**	202.8	**	323.7	*
Error	50	660.5		9.8		4.7		4.5		499.4		24.1		5.9		22.5	
HOLL Error	16	869.7		11.0		3.4		4.2		613.3		32.9		5.3		29.8	
HONL Error	16	160.0		5.4		2.1		3.3		104.1		19.6		8.1		23.7	
NONL Error	16	961.1		13.9		6.9		6.2		790.0		22.9		4.9		15.8	
Class Error	2	586.2		2.1		18.8		1.7		425.0		0.4		0.8		8.5	
CV (%)¶		4.2		6.1		2.9		4.9		10.1		1.4		1.4		2.7	

		Mean Squares							
Sources of Variation	df	Yield (kg ha^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	458591.8	**	1	37.7	**	283.3	**	0.2	*
Genotype	50	171991.3	**	50	10.2	**	65.9	**	0.1	**
HOLL	16	270854.8	**	16	9.3	*	76.4	**	0.1	**
HONL	16	129336.1	**	16	10.5	**	84.0	**	0.1	**
NONL	16	61349.2	*	16	10.4	**	44.8	**	0.1	*
Class	2	607461.7	ns	2	13.0	ns	6.2	ns	0.0	ns
Error	50	47274.7		50	3.1		13.3		0.0	
HOLL Error	16	85490.9		16	4.2		17.4		0.0	
HONL Error	16	29744.3		16	2.5		9.8		0.0	
NONL Error	16	25606.0		16	1.6		11.0		0.0	
Class Error	2	55138.0		2	11.1		25.9		0.1	
CV (%)		5.7			6.4		4.2		16.0	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B9. Analysis of variance for population 4 at Atlantic, IA, in 2009.

		Mean Squares															
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})		Seed Wt. (mg seed^{-1})	
Replication	1	17.9	ns	0.0	ns	9.5	*	5.6	ns	15.8	ns	20.8	ns	9.3	ns	51.6	ns
Genotype	71	143422.7	**	941.1	**	456.6	**	29.1	**	111649.9	**	98.6	**	34.4	**	252.3	**
HOLL	23	661.0	**	7.0	ns	16.7	**	23.1	**	495.1	**	78.4	**	22.6	**	258.4	**
HONL	23	841.9	ns	34.7	**	25.4	**	14.7	**	619.3	ns	49.8	**	23.1	**	124.3	**
NONL	23	560.5	ns	140.1	**	17.1	**	34.9	**	758.0	ns	68.1	**	23.0	**	276.1	**
Class	2	5067135.4	**	31297.9	**	15528.9	**	197.2	**	3941518.1	**	1249.2	**	432.9	**	1383.7	**
Error	69	468.8		7.6		2.5		4.0		401.0		18.9		2.8		42.2	
HOLL Error	23	231.9		6.0		1.3		6.1		162.0		28.8		3.9		68.8	
HONL Error	22	637.8		10.8		4.2		2.1		585.0		18.5		2.0		23.6	
NONL Error	22	577.4		6.0		2.1		3.8		487.8		8.2		2.3		36.0	
Class Error	2	104.8		11.9		0.6		1.4		148.9		24.3		2.7		5.6	
CV (%)¶		3.6		5.4		2.1		4.8		8.8		1.2		0.9		3.3	

		Mean Squares							
Sources of Variation	df	Yield (kg ha^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	571983.0	**	1	0.0	ns	552.1	**	0.6	*
Genotype	71	238054.9	**	71	6.5	**	66.1	**	0.3	**
HOLL	23	240690.4	**	23	4.0	**	48.8	**	0.2	ns
HONL	23	259874.0	**	23	7.6	**	76.9	**	0.2	ns
NONL	23	131422.3	**	23	7.0	**	54.5	**	0.3	*
Class	2	1179139.9	**	2	16.7	**	271.0	*	1.1	ns
Error	69	55781.0		70	0.6		15.4		0.1	
HOLL Error	23	86016.1		23	0.4		14.8		0.1	
HONL Error	22	39614.9		22	1.0		15.7		0.1	
NONL Error	22	43860.3		23	0.6		16.6		0.2	
Class Error	2	19408.1		2	0.2		7.8		0.2	
CV (%)		5.7			3.2		3.8		18.8	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B10. Analysis of variance for population 4 at Hedrick, IA, in 2009.

		Mean Squares																	
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})		Seed Wt. (mg seed^{-1})	
Replication	1	2000.6	ns‡	10.7	ns	5.5	ns	0.7	ns	1582.2	ns	22.9	ns	13.6	ns	3.4	ns
Genotype	71	139930.5	**	914.3	**	455.7	**	32.7	**	109064.6	**	55.9	**	39.6	**	166.9	**
HOLL	23	719.4	**	7.8	ns	14.5	**	32.2	**	487.5	*	76.1	**	24.3	**	210.3	**
HONL	23	1151.9	ns	34.9	**	25.3	**	24.1	**	795.9	ns	33.5	ns	29.5	**	104.1	**
NONL	23	1135.0	ns	157.0	**	22.3	**	32.6	**	1330.1	*	50.7	*	25.0	**	188.8	**
Class	2	4932522.5	**	30162.2	**	15462.9	**	137.2	*	3841272.3	**	134.0	ns	498.3	**	133.8	ns
Error	70	578.0		5.0		4.3		5.4		476.5		21.0		4.3		21.5	
HOLL Error	23	293.1		4.3		3.2		5.8		230.8		22.3		3.5		14.5	
HONL Error	22	694.9		4.1		2.6		6.2		576.4		17.8		2.2		31.0	
NONL Error	23	758.1		6.2		7.4		4.4		629.5		22.4		7.5		18.4	
Class Error	2	287.9		8.3		0.2		5.3		258.8		28.1		0.2		36.3	
CV (%)¶		4.0		4.3		2.8		5.3		9.5		1.3		1.2		2.6	

		Mean Squares							
Sources of Variation	df	Yield (kg ha^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	112753.5	ns	1	19.0	**	490.8	**	0.3	*
Genotype	71	158822.7	**	71	6.7	**	55.8	**	0.1	**
HOLL	23	191441.9	**	23	6.2	**	39.5	**	0.1	**
HONL	23	144394.7	ns	23	6.5	**	72.9	**	0.1	*
NONL	23	135750.2	*	23	6.9	**	53.5	**	0.1	**
Class	2	203575.9	ns	2	11.0	ns	67.7	ns	0.3	ns
Error	70	84863.5		70	1.6		15.7		0.0	
HOLL Error	23	67726.8		23	1.0		12.4		0.0	
HONL Error	22	107001.8		22	1.0		22.4		0.1	
NONL Error	23	69456.4		23	2.7		13.5		0.0	
Class Error	2	229960.4		2	3.2		9.6		0.2	
CV (%)		7.4			4.6		4.2		14.8	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B11. Analysis of variance for population 4 at Washington, IA, in 2009.

		Mean Squares																	
Sources of Variation†	df	Oleate (g kg^{-1})		Linolenate (g kg^{-1})		Palmitate (g kg^{-1})		Stearate (g kg^{-1})		Linoleate (g kg^{-1})		Protein (g kg^{-1} §)		Oil (g kg^{-1})		Seed Wt. (mg seed^{-1})	
Replication	1	1133.5	ns‡	3.3	ns	16.0	*	3.8	ns	933.9	ns	115.0	**	38.6	**	7.2	ns
Genotype	71	139884.6	**	829.7	**	415.0	**	33.8	**	111140.3	**	67.8	**	60.4	**	173.7	**
HOLL	23	1084.9	ns	8.5	ns	16.6	**	38.2	**	722.0	ns	50.0	**	37.4	**	202.6	**
HONL	23	624.9	**	43.9	**	24.5	**	29.3	**	235.1	ns	59.0	**	43.8	**	103.9	**
NONL	23	1214.4	**	142.4	**	26.4	**	27.9	*	1438.3	**	64.9	**	49.0	**	211.5	**
Class	2	4929602.3	**	27208.1	**	13943.3	**	102.0	*	3915750.0	**	410.6	**	648.1	**	207.5	*
Error	68	426.2		5.3		4.2		7.6		340.5		9.5		4.2		10.3	
HOLL Error	22	756.5		5.4		4.7		3.7		591.5		14.9		5.7		13.2	
HONL Error	22	153.0		3.5		2.9		7.2		127.9		6.5		3.8		6.9	
NONL Error	22	391.5		7.3		5.1		12.2		319.6		7.2		3.3		11.4	
Class Error	2	139.7		4.0		4.3		4.9		102.3		6.3		2.8		4.3	
CV (%)¶		3.4		4.6		2.8		6.2		8.1		0.9		1.2		1.7	

		Mean Squares							
Sources of Variation	df	Yield (kg ha^{-1})		df	Maturity (days #)		Height (cm)		Lodging (score ††)	
Replication	1	186845.5	ns	1	8.6	**	36.5	ns	3.4	**
Genotype	71	262266.3	**	71	15.1	**	49.8	**	0.3	**
HOLL	23	317108.2	**	23	7.4	**	31.3	ns	0.3	ns
HONL	23	221091.0	**	23	17.2	**	58.4	**	0.2	**
NONL	23	226554.7	**	23	20.7	**	50.4	*	0.4	**
Class	2	512419.1	ns	2	16.5	ns	155.6	ns	0.1	ns
Error	70	59607.2		70	1.3		17.8		0.1	
HOLL Error	23	57051.1		23	1.2		18.5		0.2	
HONL Error	22	68735.7		22	1.4		11.1		0.1	
NONL Error	23	48685.7		23	1.1		23.0		0.1	
Class Error	2	118282.5		2	2.0		25.8		0.0	
CV (%)		6.1			3.8		5.1		17.8	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

¶ = Coefficient of variation

= Days after 31 August

†† = Score 1 (all plants erect) to 5 (all plants prostrate)

Table B12. Analysis of variance of the four populations at Princeton, IL, in 2009.

	Mean Squares											
	Population											
	1			2			3			4		
Sources of Variation†	df	Yield (kg ha^{-1})		df	Yield (kg ha^{-1})		df	Yield (kg ha^{-1})		df	Yield (kg ha^{-1})	
Replication	1	905701.8	**	1	80355.1	ns‡	1	153298.9	ns	1	148820.9	ns
Genotype	41	126680.8	ns	47	181839.5	**	50	186220.1	**	71	139355.3	**
HOLL	13	176817.4	*	15	169240.3	*	16	136319.8	**	23	136665.9	**
HONL	13	141161.2	*	15	235259.8	**	16	259783.1	**	23	153728.2	*
NONL	13	69221.7	ns	15	102541.2	ns	16	185286.2	*	23	127525.1	ns
Class	2	80154.9	ns	2	470417.6	ns	2	4390.0	ns	2	77058.8	ns
Error	41	81421.8		47	59678.3		50	61982.9		63	59954.0	
HOLL Error	13	67523.5		15	67530.5		16	46401.3		23	48279.2	
HONL Error	13	54507.9		15	44267.5		16	53012.6		17	57684.5	
NONL Error	13	133970.9		15	52597.0		16	76157.8		21	78618.8	
Class Error	2	5132.0		2	169477.8		2	145000.0		2	84811.5	
CV (%)§		7.8			6.8			6.9			6.8	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Coefficient of variation

Table B13. Analysis of variance of all four populations at Napoleon, OH, in 2009.

	Mean Squares											
	Population											
	1			2			3			4		
Sources of Variation†	df	Yield (kg ha^{-1})		df	Yield (kg ha^{-1})		df	Yield (kg ha^{-1})		df	Yield (kg ha^{-1})	
Replication	1	30330.9	ns‡	1	173782.4	ns	1	828555.2	*	1	0.6	ns
Genotype	41	221460.3	ns	47	190719.3	ns	50	183857.8	ns	71	220853.5	**
HOLL	13	326543.5	ns	15	263056.4	ns	16	176092.3	ns	23	242090.6	ns
HONL	13	190945.6	ns	15	147428.7	ns	16	179959.9	ns	23	151529.0	ns
NONL	13	71797.4	ns	15	97752.6	ns	16	187111.2	ns	23	214740.2	**
Class	2	703163.6	*	2	673150.5	*	2	251138.3	ns	2	834378.5	ns
Error	40	239749.3		46	169716.0		50	149324.2		68	107468.8	
HOLL Error	13	189934.3		15	270949.7		16	97851.6		23	125344.3	
HONL Error	13	331597.8		15	116518.5		16	215259.5		20	117764.4	
NONL Error	12	227561.6		14	138617.2		16	150108.0		23	74979.0	
Class Error	2	40616.0		2	21751.1		2	27351.3		2	172709.2	
CV (%)§		13.3			10.4			9.5			8.0	

*Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$

†= HOLL = High-oleate/low-linolenate lines, HONL = high-oleate/normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines

‡ns = Not significant at the 0.05 probability level.

§ = Coefficient of variation

APPENDIX C

CLASS AND ENTRY MEANS FOR AGRONOMIC AND SEED TRAITS AT INDIVIDUAL ENVIRONMENTS

Table C1. Mean performance and agronomic seed traits of 14 high-oleate/low-linolenate, 14 high-oleate/normal-linolenate, and 14 normal-oleate/normal-linolenate lines from population 1 in 2009.

		Environment									
		Dallas Center, IA		Denison, IA		Conrad, IA		Napoleon, OH		Princeton, IL	
Trait	Class†	Mean‡	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Oleate	HOLL	785 a	772-804**	777 a	738-801ns§	767 a	698-794ns				
(g kg^{-1})	HONL	785 a	761-805ns	773 a	716-802ns	763 a	672-804**				
	NONL	225 b	201-274ns	223 b	203-280ns	219 b	204-251*				
Linolenate	HOLL	23 a	22-29ns	23 a	21-28ns	25 a	22-28ns				
(g kg^{-1})	HONL	53 b	46-58ns	54 b	50-65**	57 b	51-64*				
	NONL	74 c	44-88**	75 c	42-89**	78 c	45-91**				
Linoleate	HOLL	75 a	60-90**	85 a	66-123ns	93 a	74-157ns				
(g kg^{-1})	HONL	49 b	33-78ns	61 b	37-105ns	67 b	37-147**				
	NONL	551 c	515-588*	551 c	492-579ns	554 c	510-583**				
Palmitate	HOLL	69 a	63-74**	72 a	67-78**	71 a	67-77ns				
(g kg^{-1})	HONL	67 b	63-76**	71 a	66-83**	70 a	64-77**				
	NONL	104 c	98-115**	108 b	98-118**	105 b	96-115**				
Stearate	HOLL	48 a	43-58**	43 a	36-47**	44 a	40-52**				
(g kg^{-1})	HONL	46 b	38-51**	41 b	37-47ns	43 a	37-50ns				
	NONL	46 b	40-54**	43 a	39-49**	44 a	40-51*				
Yield	HOLL	3949 a	3282-4425**	4010 a	2757-4818**	4187 a	3117-4677**	3555 a	2959-4395ns	3674 a	3043-4045*
(kg ha^{-1})	HONL	4011 a	3534-4227*	3979 a	3433-4418**	4322 ab	3914-4839ns	3642 a	3006-4106ns	3588 a	3100-3954*
	NONL	4033 a	3383-4580*	4260 b	3803-4691*	4423 b	3887-4822*	3868 a	3635-4133ns	3687 a	3366-4092ns
Maturity	HOLL	25 a	18-30**	28 a	22-33**	30 a	26-33**				
(days¶)	HONL	25 a	17-29**	27 ab	21-33**	29 b	24-33**				
	NONL	23 b	16-28**	26 b	21-31**	29 b	24-33**				

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.

‡ = Means within a column and trait followed by the same letter were not significantly different at the 0.05 probability level based on Tukey's honestly significant difference (Tukey, 1949).

* Significant difference at $p \leq 0.05$ among lines within a class.

** Significant difference at $p \leq 0.01$ among lines within a class.

§ns = differences among lines within a class were not significant at the 0.05 probability level.

¶ Days after 31 August.

Score 1 (all plants erect) to 5 (all plants prostrate).

†† Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

Table C1. Continued

		Environment									
		Dallas Center, IA		Denison, IA		Conrad, IA		Napoleon, OH		Princeton, IL	
Trait	Class†	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Height	HOLL	100 a	92-110**	111 a	101-124**	88 a	73-96*				
(cm)	HONL	100 a	84-110**	116 b	106-126**	92 b	78-102*				
	NONL	100 a	86-111**	113 a	107-122ns	91 ab	81-99**				
Lodging	HOLL	1.8 a	1.0-3.0**	2.2 a	1.3-3.3*	2.1 a	1.5-3.3**				
(score #)	HONL	2.1 b	1.3-3.3*	2.5 a	1.3-3.8**	2.6 b	1.3-3.8**				
	NONL	1.8 a	1.0-2.8*	2.3 a	1.0-3.3**	2.2 a	1.3-3.8**				
Protein	HOLL	354 a	346-365**	351 a	345-363**	360 a	349-370ns				
(g kg^{-1} ††)	HONL	357 b	345-375**	354 b	342-368**	363 b	353-374**				
	NONL	350 c	339-363**	348 c	337-369**	360 a	348-375**				
Oil	HOLL	177 a	170-184**	181 a	175-189**	175 a	171-185**				
(g kg^{-1} ††)	HONL	178 a	170-186**	181 a	173-188**	177 b	171-185**				
	NONL	184 b	173-191**	184 b	179-192**	180 c	172-189**				
Seed Wt.	HOLL	177 a	163-195**	179 a	159-205**	178 a	164-189**				
(mg sd^{-1})	HONL	183 b	167-216**	185 b	167-231**	183 b	167-207**				
	NONL	180 c	166-197**	186 b	166-206**	184 b	171-193**				

Table C2. Mean performance and agronomic seed traits of 16 high-oleate/low-linolenate, 16 high-oleate/normal-linolenate, and 16 normal-oleate/normal-linolenate lines from population 2 in 2009.

		Environment									
		Atlantic, IA		Hedrick, IA		Washington, IA		Napoleon, OH		Princeton, IL	
Trait	Class†	Mean‡	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Oleate	HOLL	784 a	737-805**	788 a	722-809ns§	788 a	735-812ns				
(g kg^{-1})	HONL	782 a	693-809**	783 a	721-807ns	782 a	665-812**				
	NONL	212 b	195-225ns	233 b	201-323**	231 b	205-311**				
Linolenate	HOLL	23 a	21-26ns	24 a	19-31ns	23 a	20-26ns				
(g kg^{-1})	HONL	58 b	51-74**	55 b	50-63**	54 b	48-64**				
	NONL	77 c	59-93**	74 c	63-87**	73 c	62-88**				
Linoleate	HOLL	87 a	65-133**	81 a	60-138ns	80	58-123ns				
(g kg^{-1})	HONL	53 b	30-142**	54 b	34-116ns	55	33-170**				
	NONL	566 c	539-592**	548 c	455-583**	550	467-579**				
Palmitate	HOLL	68 a	63-74**	65 a	59-70**	66 a	60-71**				
(g kg^{-1})	HONL	68 a	63-73**	65 a	60-73*	65 a	59-71**				
	NONL	102 b	94-107**	98 b	92-105**	97 b	90-104**				
Stearate	HOLL	38 a	33-41*	42 a	36-48**	43 a	37-50**				
(g kg^{-1})	HONL	39 a	36-47ns	43 a	41-47ns	44 a	40-55**				
	NONL	43 b	38-49**	47 b	43-56**	49 b	42-59**				
Yield	HOLL	4009 a	2747-4489**	4019 a	2912-4412*	4335 ab	2919-4711**	3858 a	3077-4412ns	3462 a	2781-3931*
(kg ha^{-1})	HONL	4156 a	3675-4687ns	3921 a	3450-4361ns	4287 b	3964-4671*	3932 ab	3389-4314ns	3653 b	3030-4143**
	NONL	4334 b	4015-4825ns	4048 a	3615-4546*	4427 a	3884-4923**	4140 b	3773-4674ns	3687 b	3238-4129ns
Maturity	HOLL	27 a	23-31**	29 a	26-33**	27 a	24-30*				
(days¶)	HONL	26 b	23-29**	28 a	25-32*	26 b	24-33**				
	NONL	26 b	23-29**	28 a	26-35**	26 b	24-32**				

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.

‡ = Means within a column and trait followed by the same letter were not significantly different at the 0.05 probability level based on Tukey's honestly significant difference (Tukey, 1949).

* Significant difference at $p \leq 0.05$ among lines within a class.

** Significant difference at $p \leq 0.01$ among lines within a class.

§ns = differences among lines within a class were not significant at the 0.05 probability level.

¶ Days after 31 August.

Score 1 (all plants erect) to 5 (all plants prostrate).

†† Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

Table C2. Continued

		Environment									
		Atlantic, IA		Hedrick, IA		Washington, IA		Napoleon, OH		Princeton, IL	
Trait	Class†	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Height	HOLL	102 a	92-112**	86 a	77-91*	82 a	70-91**				
(cm)	HONL	101 a	95-108**	85 a	76-91**	83 a	73-88*				
	NONL	101 a	89-110**	85 a	76-93ns	82 a	68-91**				
Lodging	HOLL	1.9 a	1.5-2.3**	1.5 a	1.3-2.0ns	1.7 a	1.3-2.0**				
(score #)	HONL	1.9 a	1.3-2.3**	1.4 ab	1.0-1.8ns	1.6 a	1.0-2.0**				
	NONL	1.9 a	1.5-2.3ns	1.3 b	1.0-1.5ns	1.4 b	1.0-1.8*				
Protein	HOLL	358 a	348-367**	356 a	345-366**	357 a	348-369**				
(g kg^{-1} ††)	HONL	358 a	349-367**	356 a	348-374**	359 b	351-373**				
	NONL	349 b	341-358**	351 b	343-359**	354 c	346-362**				
Oil	HOLL	175 a	169-182**	171 a	166-176**	170 a	165-177**				
(g kg^{-1} ††)	HONL	175 a	170-182**	172 a	166-182**	171 b	163-184**				
	NONL	179 b	174-185**	177 b	171-183**	176 c	168-181**				
Seed Wt.	HOLL	178 a	155-195**	167 a	151-180**	167 a	151-184**				
(mg sd^{-1})	HONL	184 b	170-199**	170 b	162-184**	173 b	164-188**				
	NONL	187 b	173-202**	171 b	159-187**	175 c	161-193**				

Table C3. Mean performance and agronomic seed traits of 17 high-oleate/low-linolenate, 17 high-oleate/normal-linolenate, and 17 normal-oleate/normal-linolenate lines from population 3 in 2009.

		Environment									
		Atlantic, IA		Hedrick, IA		Washington, IA§		Napoleon, OH		Princeton, IL	
Trait	Class†	Mean‡	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Oleate	HOLL	793 a	767-814ns¶	789 a	749-817ns	790	701-816				
(g kg^{-1})	HONL	795 a	762-812**	800 a	774-814ns	785	668-814				
	NONL	227 b	202-271ns	238 b	209-285ns	227	206-291				
Linolenate	HOLL	22 a	19-24ns	24 a	19-28ns	22	20-26				
(g kg^{-1})	HONL	57 b	49-68**	53 b	47-62**	56	48-67				
	NONL	80 c	69-97**	77 c	62-91**	77	60-91				
Linoleate	HOLL	78 a	61-100*	78 a	57-111ns	77	58-160				
(g kg^{-1})	HONL	45 b	33-71**	44 b	29-66ns	55	30-154				
	NONL	552 c	507-578ns	544 c	506-586ns	554	504-581				
Palmitate	HOLL	67 a	62-75**	65 a	60-72**	66	60-73				
(g kg^{-1})	HONL	65 b	60-70**	62 b	59-65**	62	59-68				
	NONL	100 c	94-107**	96 c	92-101*	96	90-102				
Stearate	HOLL	40 a	37-45**	44 a	39-49**	45	39-50				
(g kg^{-1})	HONL	38 b	32-43**	41 b	37-46**	42	38-48				
	NONL	41 c	35-48**	45 a	38-55**	46	36-62				
Yield	HOLL	3905 a	3315-4512**	3652 a	3046-4280**	4236	3793-4728	3982 a	3228-4533ns	3622 a	3107-3985**
(kg ha^{-1})	HONL	3985 a	2915-4795**	3901 b	3393-4328**	4283	3531-4586	4036 a	3285-4395ns	3602 a	2841-3995**
	NONL	4225 b	3447-4758**	3860 b	3514-4260*	4382	3934-4923	4150 a	3655-4741ns	3622 a	2898-4048*
Maturity	HOLL	25 a	22-29**	27 a	24-32*	28	24-33				
(days#)	HONL	26 b	23-29**	28 a	25-34**	27	24-34				
	NONL	26 b	23-30**	28 a	25-32**	28	24-34				

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Means within a column and trait followed by the same letter were not significantly different at the 0.05 probability level based on Tukey's honestly significant difference (Tukey, 1949).
* Significant difference at $p \leq 0.05$ among lines within a class.
** Significant difference at $p \leq 0.01$ among lines within a class.
§ = Significance was unable to be determined.
¶ ns = differences among lines within a class were not significant at the 0.05 probability level.
# Days after 31 August.
†† Score 1 (all plants erect) to 5 (all plants prostrate).
‡‡ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

Table C3. Continued

		Environment									
		Atlantic, IA		Hedrick, IA		Washington, IA		Napoleon, OH		Princeton, IL	
Trait	Class†	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Height	HOLL	100 a	88-116**	87 a	75-97**	86	70-96				
(cm)	HONL	103 b	85-114**	87 a	77-100**	87	78-100				
	NONL	104 b	97-111**	87 a	80-101**	87	78-102				
Lodging	HOLL	2.1 a	1.5-3.3**	1.3 a	1.0-1.8**	1.4	1.0-2.0				
(score ††)	HONL	2.1 a	1.5-3.5**	1.3 a	1.0-2.0**	1.5	1.0-2.5				
	NONL	2.1 a	1.0-3.0**	1.3 a	1.0-1.8*	1.6	1.0-3.0				
Protein	HOLL	364 a	358-379**	354 a	342-366*	365	359-379				
(g kg^{-1} ‡‡)	HONL	365 a	356-379**	359 b	350-371**	367	358-376				
	NONL	353 b	345-363**	352 a	343-360ns	360	352-366				
Oil	HOLL	180 a	174-190**	178 a	171-184**	173	167-182				
(g kg^{-1} ‡‡)	HONL	179 a	172-187**	177 a	168-184**	174	163-181				
	NONL	183 b	175-192**	182 b	174-191**	178	170-190				
Seed Wt.	HOLL	197 a	180-219**	177 a	158-198**	183	168-200				
(mg sd^{-1})	HONL	192 b	173-207**	177 a	161-189**	178	169-192				
	NONL	192 b	174-211**	172 b	153-184**	176	158-190				

Table C4. Mean performance and agronomic seed traits of 24 high-oleate/low-linolenate, 24 high-oleate/normal-linolenate, and 24 normal-oleate/normal-linolenate lines from population 4 in 2009.

		Environment									
		Atlantic, IA		Hedrick, IA		Washington, IA		Napoleon, OH		Princeton, IL	
Trait	Class†	Mean‡	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Oleate	HOLL	794 a	733-814**	791 a	736-814**	790 a	731-825ns§				
(g kg^{-1})	HONL	790 a	709-812ns	784 a	713-815ns	792 a	736-812**				
	NONL	222 b	200-260ns	231 b	203-302ns	231 b	204-307**				
Linolenate	HOLL	23 a	20-29ns	24 a	21-29ns	23 a	21-30ns				
(g kg^{-1})	HONL	58 b	50-66**	58 b	50-64**	57 b	49-65**				
	NONL	74 c	45-86**	73 c	43-86**	70 c	42-83**				
Linoleate	HOLL	78 a	60-130**	77 a	59-125*	78 a	55-128ns				
(g kg^{-1})	HONL	47 b	32-115ns	52 b	32-111ns	44 b	33-79ns				
	NONL	563 c	519-598ns	555 c	479-590*	560 c	478-598**				
Palmitate	HOLL	65 a	61-73**	64 a	59-69**	64 a	59-70**				
(g kg^{-1})	HONL	65 a	58-72**	64 a	58-69**	64 a	57-69**				
	NONL	97 b	93-103**	95 b	89-102**	93 b	87-102**				
Stearate	HOLL	40 a	35-49**	44 a	33-51**	45 a	36-53**				
(g kg^{-1})	HONL	40 a	36-46**	42 b	37-49**	43 b	37-54**				
	NONL	44 b	37-54**	46 c	40-54**	46 a	37-53*				
Yield	HOLL	3979 a	3215-4627**	3902 a	3201-4344**	3912 a	3130-4560**	3971 a	2976-4482ns	3551 a	2861-3853**
(kg ha^{-1})	HONL	4112 b	3272-4580**	3881 a	3272-4358ns	3995 a	3231-4519**	4021 a	3406-4634ns	3605 a	2835-4045*
	NONL	4292 c	3806-4667**	4002 a	3521-4321*	4117 b	3406-4805**	4222 b	3531-4714**	3629 a	2515-4089ns
Maturity	HOLL	25 a	22-27**	27 a	24-31**	29 a	26-33**				
(days¶)	HONL	25 a	20-30**	27 a	24-32**	30 b	26-39**				
	NONL	26 b	23-31**	28 b	24-32**	30 b	27-41**				

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.

‡ = Means within a column and trait followed by the same letter were not significantly different at the 0.05 probability level based on Tukey's honestly significant difference (Tukey, 1949).

* Significant difference at $p \leq 0.05$ among lines within a class.

** Significant difference at $p \leq 0.01$ among lines within a class.

§ns = differences among lines within a class were not significant at the 0.05 probability level.

¶ Days after 31 August.

Score 1 (all plants erect) to 5 (all plants prostrate).

†† Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

Table C4. Continued

		Environment									
		Atlantic, IA		Hedrick, IA		Washington, IA		Napoleon, OH		Princeton, IL	
Trait	Class†	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Height	HOLL	100 a	93-108**	91 a	84-100**	82 a	76-91ns				
(cm)	HONL	101 a	90-112**	93 b	82-106**	83 ab	73-93**				
	NONL	105 b	91-116**	94 b	81-101**	85 b	74-94*				
Lodging	HOLL	1.7 a	1.3-2.3ns	1.5 a	1.0-2.0**	2.1 a	1.5-3.0ns				
(score #)	HONL	1.9 b	1.3-2.5ns	1.5 a	1.0-2.0*	2.0 a	1.5-2.8**				
	NONL	2.0 b	1.3-2.8*	1.4 a	1.0-1.8**	2.1 a	1.5-3.8**				
Protein	HOLL	357 a	346-371**	350 a	339-361**	360 a	351-370**				
(g kg^{-1} ††)	HONL	360 b	351-368**	350 a	343-357ns	360 a	350-369**				
	NONL	350 c	340-362**	347 b	336-356*	355 b	345-367**				
Oil	HOLL	179 a	173-185**	177 a	172-184**	173 a	167-181**				
(g kg^{-1} ††)	HONL	179 a	171-184**	177 a	171-187**	174 a	166-183**				
	NONL	185 b	180-191**	182 b	175-188**	180 b	171-189**				
Seed Wt.	HOLL	193 a	171-215**	175 a	161-192**	189 a	171-210**				
(mg sd^{-1})	HONL	202 b	186-220**	178 b	166-193**	194 b	181-211**				
	NONL	202 b	181-220**	176 ab	154-192**	191 c	171-207**				

Table C5. Mean performance of 14 high-oleate/low-linolenate, 14 high-oleate/normal-linolenate, and 14 normal-oleate/normal-linolenate lines from population 1 grown at Conrad, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	769	28	72	44	87	4247	30	91	2.8	360	171	187
8	HOLL	769	26	67	44	94	4233	32	95	3.3	357	175	189
9	HOLL	794	22	67	40	77	4018	31	90	2.0	349	185	171
10	HOLL	778	23	70	45	84	4395	32	89	2.3	360	183	175
11	HOLL	698	26	73	45	158	3615	30	82	2.0	360	176	164
12	HOLL	775	24	72	52	77	3117	29	82	2.3	360	172	184
13	HOLL	777	26	68	45	84	4459	30	88	2.0	356	178	187
14	HOLL	749	25	77	45	104	3813	26	73	1.5	361	176	177
15	HOLL	776	23	72	43	86	4445	33	91	3.0	370	173	178
16	HOLL	770	24	73	43	90	4586	28	89	1.5	367	171	171
17	HOLL	790	24	69	42	75	4449	27	84	1.5	366	178	186
18	HOLL	732	25	75	50	118	4344	31	88	2.0	352	173	171
19	HOLL	779	24	72	43	82	4677	30	96	2.0	362	175	183
20	HOLL	760	26	73	40	101	4217	31	93	1.8	366	173	177
21	HONL	736	62	71	40	91	4052	30	92	3.0	374	173	187
22	HONL	721	64	75	41	99	4839	28	97	2.3	363	174	180
23	HONL	793	52	68	42	45	3981	29	93	3.3	359	182	181
24	HONL	755	58	77	50	60	4402	27	91	1.5	365	178	182
25	HONL	779	59	64	46	52	4311	29	90	1.8	374	171	174
26	HONL	797	54	67	37	45	4291	24	78	1.8	358	177	179
27	HONL	704	51	73	40	132	4442	31	90	2.5	353	176	189
28	HONL	792	59	66	45	38	4354	32	102	3.5	368	175	207
29	HONL	764	57	70	45	64	4260	28	99	2.8	365	179	202

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C5. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	672	63	74	43	148	4415	33	97	3.3	363	171	169
31	HONL	782	57	70	43	48	4472	25	82	1.3	365	182	167
32	HONL	804	51	66	41	38	4435	33	93	3.0	353	182	180
33	HONL	793	51	69	43	44	3914	29	87	2.3	355	185	185
34	HONL	778	56	73	43	50	4344	33	97	3.8	368	175	179
35	NONL	227	45	100	44	584	4146	28	87	1.5	360	187	188
36	NONL	212	88	115	47	538	4075	24	86	2.0	359	179	177
37	NONL	206	75	110	45	564	4654	27	91	2.8	348	186	171
38	NONL	216	72	107	50	555	3887	32	83	2.0	356	180	171
39	NONL	207	79	108	46	560	3941	28	81	1.8	349	189	186
40	NONL	206	82	100	43	569	4240	33	98	2.5	369	172	182
41	NONL	218	71	108	51	552	4805	30	94	2.8	354	181	173
42	NONL	208	78	104	43	567	4163	32	91	2.5	356	176	190
43	NONL	217	76	102	40	565	4627	31	96	2.5	363	177	193
44	NONL	217	73	107	41	562	4822	33	99	3.8	349	183	185
45	NONL	242	91	104	43	520	4704	30	94	2.0	369	179	187
46	NONL	204	91	96	41	568	4617	27	90	1.8	367	180	192
47	NONL	251	88	108	42	511	4586	28	94	2.0	375	177	193
48	NONL	208	88	108	45	551	4654	30	88	1.3	358	186	189
SEM		19	2	2	2	16	164	1	3	0	3	1	3
LSD 0.05		53	6	5	5	47	469	2	10	1	9	4	8
LSD 0.01		71	8	7	6	63	627	3	13	1	12	4	11
92M61	Check	208	88	101	36	567	4382	26	88	1.5	343	191	152
92Y80	Check	222	89	102	51	536	4320	29	82	1.8	362	187	174
93M11	Check	235	81	97	56	531	4018	32	80	1.0	345	194	156
93M42	Check	245	81	101	62	511	4219	33	94	2.5	358	165	166
92Y80#	Check	211	88	110	42	549	4286	27	84	1.5	365	187	176
92Y30	Check	222	88	99	41	550	3957	22	76	1.8	344	190	145

Table C6. Mean performance of 14 high-oleate/low-linolenate, 14 high-oleate/normal-linolenate, and 14 normal-oleate/normal-linolenate lines from population 1 grown at Dallas Center, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	775	29	71	50	75	4065	27	100	2.8	361	170	195
8	HOLL	776	23	67	44	90	4425	29	105	2.3	346	176	193
9	HOLL	802	22	63	45	68	4136	27	104	1.8	350	184	175
10	HOLL	784	24	65	51	76	3621	27	95	2.3	350	180	167
11	HOLL	788	22	67	50	73	3628	26	92	1.5	353	178	163
12	HOLL	779	23	70	58	70	3282	25	95	1.8	355	176	181
13	HOLL	789	24	67	47	73	3944	23	103	1.8	347	181	184
14	HOLL	786	23	74	45	72	3810	18	92	1.8	361	178	177
15	HOLL	772	25	72	47	84	4210	30	110	3.0	363	173	177
16	HOLL	777	23	71	48	81	4180	24	99	1.5	359	174	172
17	HOLL	804	22	70	45	59	4139	20	98	1.5	365	180	187
18	HOLL	775	23	70	54	78	3695	25	103	1.0	346	173	169
19	HOLL	785	22	70	43	80	4186	27	106	1.3	350	180	171
20	HOLL	790	23	72	43	72	3964	25	100	1.5	356	177	176
21	HONL	762	57	68	42	71	4139	25	100	2.8	375	176	192
22	HONL	776	58	68	46	52	4162	24	95	1.5	352	177	171
23	HONL	774	46	69	43	68	3534	24	105	2.5	345	186	180
24	HONL	771	53	76	51	49	3786	23	100	1.3	354	179	179
25	HONL	792	56	66	46	40	4102	24	101	2.0	367	170	177
26	HONL	805	53	66	38	38	4096	17	84	1.3	362	177	185
27	HONL	761	50	66	45	78	4227	27	105	1.5	345	176	191
28	HONL	793	54	64	50	39	4052	28	106	2.5	361	175	216
29	HONL	802	48	67	49	34	3783	25	98	2.3	358	186	191

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C6. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	772	53	66	50	59	4217	27	100	2.0	345	176	167
31	HONL	798	52	69	47	34	3991	18	85	1.3	361	183	175
32	HONL	802	51	63	47	37	4129	29	109	2.0	346	183	172
33	HONL	794	52	70	42	42	3766	26	106	3.3	364	184	191
34	HONL	788	54	67	47	44	4170	29	110	3.3	360	175	169
35	NONL	218	44	108	43	587	3921	22	93	1.5	350	191	183
36	NONL	220	85	115	47	533	3383	16	86	1.5	356	181	169
37	NONL	212	71	109	48	560	3927	23	98	2.3	341	189	169
38	NONL	211	70	106	45	568	3756	24	102	1.8	343	185	166
39	NONL	205	77	110	49	559	3702	21	93	1.8	341	191	185
40	NONL	218	84	98	48	552	3985	28	110	1.5	361	173	175
41	NONL	218	63	105	54	560	4062	25	111	2.8	348	183	168
42	NONL	213	67	104	51	565	4324	27	104	1.8	346	179	189
43	NONL	274	67	100	44	515	4085	23	105	2.3	352	182	197
44	NONL	255	67	99	49	530	3921	28	105	2.5	339	184	185
45	NONL	220	86	105	42	547	4425	23	100	1.5	356	183	179
46	NONL	201	87	98	40	574	4580	24	103	1.8	360	182	188
47	NONL	241	88	102	45	524	4247	21	100	1.5	363	182	189
48	NONL	225	85	105	44	541	4143	23	95	1.0	346	190	186
SEM		13	2	2	2	11	142	1	3	0	3	2	3
LSD 0.05		38	6	4	5	33	405	3	8	1	9	5	7
LSD 0.01		51	8	6	6	44	542	4	11	1	12	7	10
92M61	Check	214	83	99	39	565	3974	23	97	1.0	336	193	149
92Y80	Check	219	85	109	49	538	3866	24	103	1.3	363	183	176
93M11	Check	228	73	98	55	546	4201	24	98	1.0	337	198	158
93M42	Check	225	79	106	63	527	4148	30	108	1.5	346	169	164
92Y80#	Check	212	85	107	49	547	4148	23	96	1.3	359	187	176
92Y30	Check	227	80	102	43	548	3754	16	86	1.0	334	199	151

Table C7. Mean performance of 14 high-oleate/low-linolenate, 14 high-oleate/normal-linolenate, and 14 normal-oleate/normal-linolenate lines from population 1 grown at Denison, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	775	23	76	40	86	4771	28	114	2.5	352	175	204
8	HOLL	774	23	67	47	89	4398	33	115	3.3	346	178	205
9	HOLL	798	21	68	41	72	3937	29	107	1.3	346	189	170
10	HOLL	781	21	70	46	82	3679	32	108	2.5	349	187	165
11	HOLL	738	23	73	43	123	3013	28	101	2.0	352	180	159
12	HOLL	778	21	73	46	82	2757	29	101	2.0	345	185	168
13	HOLL	775	26	71	38	90	3901	24	115	2.3	347	179	182
14	HOLL	778	22	78	42	80	4089	22	109	2.8	363	177	185
15	HOLL	770	23	74	47	86	4818	32	124	3.3	357	177	188
16	HOLL	773	28	73	43	83	4247	26	112	1.5	352	178	175
17	HOLL	801	22	70	41	66	4381	23	107	1.5	360	180	197
18	HOLL	749	27	76	46	102	3985	31	114	2.5	345	180	173
19	HOLL	784	23	73	42	78	4011	31	117	1.8	352	184	167
20	HOLL	789	22	74	36	79	4099	26	110	1.5	347	183	170
21	HONL	781	55	69	41	54	4116	28	112	3.3	368	177	196
22	HONL	716	65	77	39	103	3605	23	113	2.0	355	176	167
23	HONL	764	51	73	39	73	3739	27	119	2.8	348	187	181
24	HONL	720	53	83	46	98	3931	27	111	2.5	353	181	175
25	HONL	789	57	66	43	45	3803	24	120	2.5	365	173	189
26	HONL	798	53	68	37	44	4250	21	108	2.0	360	177	189
27	HONL	732	50	74	39	105	3433	29	106	1.5	344	183	175
28	HONL	795	54	67	47	37	4280	31	123	3.5	361	179	231
29	HONL	802	50	69	42	37	3904	24	121	3.0	359	188	203

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C7. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	752	57	72	38	81	3901	31	115	2.3	347	177	167
31	HONL	780	58	73	41	48	4418	22	107	1.3	352	184	180
32	HONL	798	53	67	42	40	4143	33	124	3.0	342	185	179
33	HONL	801	51	68	40	40	4243	26	117	1.8	351	188	179
34	HONL	775	54	74	43	54	3937	33	126	3.8	356	181	180
35	NONL	228	42	111	40	579	4267	23	107	1.8	350	188	188
36	NONL	203	89	118	44	546	3941	21	107	1.8	354	179	178
37	NONL	203	71	114	44	568	3803	21	111	2.5	351	180	166
38	NONL	206	71	110	44	569	3944	26	115	3.0	345	184	178
39	NONL	206	74	109	45	566	3981	22	109	2.5	337	192	197
40	NONL	209	79	103	44	565	4210	31	112	2.3	348	180	176
41	NONL	214	66	111	48	561	4691	29	118	3.3	340	186	177
42	NONL	216	72	105	49	558	4482	31	113	1.3	338	181	191
43	NONL	207	71	107	40	575	4351	24	122	3.0	347	183	199
44	NONL	231	70	109	42	548	3894	30	115	3.3	339	187	175
45	NONL	280	80	106	41	493	4506	29	112	3.0	357	183	198
46	NONL	236	88	98	39	539	4512	23	112	2.0	354	184	191
47	NONL	239	88	107	42	524	4610	28	115	2.0	369	179	206
48	NONL	235	85	111	41	528	4452	24	119	1.0	340	188	187
SEM		7	2	2	2	19	184	1	3	0	2	1	4
LSD 0.05		64	7	6	5	53	527	3	8	1	7	3	12
LSD 0.01		85	9	8	6	87	760	4	11	1	22	4	16
92M61	Check	202	85	103	35	575	4574	22	117	2.5	329	196	164
92Y80	Check	219	83	110	45	543	4302	23	110	1.0	350	189	170
93M11	Check	230	78	102	45	545	4353	26	104	1.0	333	198	169
93M42	Check	227	82	106	57	528	3726	32	124	2.8	343	175	156
92Y80#	Check	211	88	109	45	547	4407	23	112	1.3	357	187	167
92Y30	Check	222	84	103	38	553	3466	19	108	1.5	340	191	150

Table C8. Mean performance of 16 high-oleate/low-linolenate, 16 high-oleate/normal-linolenate, and 16 normal-oleate/normal-linolenate lines from population 2 grown at Atlantic, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	737	22	69	38	134	3726	24	98	1.5	351	178	171
8	HOLL	775	25	69	41	90	3880	31	111	1.5	348	170	187
9	HOLL	792	23	64	41	80	2747	25	99	1.5	358	179	161
10	HOLL	805	24	67	39	65	4455	27	97	2.0	352	182	178
11	HOLL	793	24	69	41	73	4432	23	101	2.3	364	181	182
12	HOLL	782	25	72	37	84	4489	26	112	2.3	363	179	188
13	HOLL	783	26	63	36	92	3833	25	104	2.0	356	170	178
14	HOLL	779	24	68	37	92	3968	27	99	2.0	352	177	167
15	HOLL	792	23	66	35	84	3978	26	96	2.3	367	172	186
16	HOLL	782	21	71	33	93	3547	25	92	1.5	363	172	155
17	HOLL	763	25	73	37	102	4348	28	102	1.5	358	174	179
18	HOLL	776	21	66	40	97	4227	30	102	2.0	365	173	195
19	HOLL	802	24	63	37	74	4122	27	100	2.0	360	169	182
20	HOLL	786	24	72	39	79	3934	30	97	2.0	356	170	186
21	HOLL	776	25	74	40	85	4176	26	107	2.3	363	176	173
22	HOLL	786	21	70	40	83	4280	30	108	2.0	362	178	190
23	HONL	793	52	66	39	50	3921	27	95	1.5	362	174	190
24	HONL	795	60	68	38	39	4217	25	104	1.8	354	175	186
25	HONL	780	65	70	38	47	3884	25	107	2.0	360	172	194
26	HONL	780	57	70	41	52	4237	25	104	2.0	364	174	194
27	HONL	693	54	70	41	142	4439	29	102	2.3	358	174	187
28	HONL	793	53	69	39	46	3675	25	96	2.3	367	170	181
29	HONL	787	58	65	47	43	4687	29	105	2.0	355	173	198

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C8. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	771	55	73	41	60	3927	29	98	2.3	362	173	184
31	HONL	800	55	68	39	38	4549	25	100	1.8	353	175	199
32	HONL	790	61	63	38	48	3914	27	101	2.0	349	172	174
33	HONL	809	55	69	36	31	4627	23	95	1.5	352	179	177
34	HONL	726	74	71	40	89	4042	24	102	2.0	364	176	178
35	HONL	787	61	71	38	43	3914	24	98	1.5	353	182	171
36	HONL	806	57	63	38	36	4109	24	100	2.0	366	173	185
37	HONL	805	51	63	40	41	4274	26	108	2.0	358	179	185
38	HONL	772	63	72	40	53	4075	25	101	1.3	353	178	170
39	NONL	209	73	101	45	572	4106	25	104	2.3	348	179	185
40	NONL	225	93	105	38	539	4119	25	89	1.5	354	177	177
41	NONL	211	88	99	47	555	4375	26	100	2.0	346	182	183
42	NONL	211	85	102	43	559	4640	25	109	2.0	344	183	196
43	NONL	203	71	107	39	580	4284	25	99	1.8	356	178	202
44	NONL	210	67	105	41	577	4257	23	106	1.8	348	179	183
45	NONL	211	73	106	41	569	4274	25	95	1.8	356	179	195
46	NONL	225	69	94	46	566	4227	28	107	2.0	353	177	188
47	NONL	195	70	101	42	592	4825	29	104	2.0	341	185	200
48	NONL	216	88	99	49	548	4381	27	106	1.8	344	179	173
49	NONL	202	71	107	43	577	4119	27	91	1.8	354	175	176
50	NONL	208	74	103	42	573	4223	24	90	1.5	347	179	193
51	NONL	219	90	94	47	550	4351	27	110	1.8	353	174	179
52	NONL	202	76	102	45	575	4734	28	108	2.3	347	180	196
53	NONL	210	89	106	43	552	4408	26	102	1.8	346	182	185
54	NONL	216	59	102	44	579	4015	26	102	2.3	358	177	191
SEM		10	2	1	1	9	188	1	2	0	2	1	4
LSD 0.05		30	6	4	4	24	534	2	7	0	6	4	11
LSD 0.01		39	8	5	6	33	712	3	9	1	8	5	15

Table C8. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
92M61	Check	207	86	99	35	573	4408	26	98	2.0	337	196	167
92Y80	Check	228	89	108	45	530	4207	26	91	1.8	365	187	189
93M11	Check	232	82	98	46	542	4343	26	92	1.0	345	198	177
93M42	Check	224	89	107	51	529	4119	29	114	1.8	348	176	170
93M11#	Check	257	78	99	45	521	4408	25	96	1.0	339	199	177
93Y11	Check	224	85	102	38	551	3905	25	101	1.5	350	190	188

Table C9. Mean performance of 16 high-oleate/low-linolenate, 16 high-oleate/normal-linolenate, and 16 normal-oleate/normal-linolenate lines from population 2 grown at Hedrick, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	789	24	62	42	83	3840	29	85	1.5	346	170	171
8	HOLL	787	25	65	45	78	3763	32	91	1.3	345	169	174
9	HOLL	802	25	61	47	65	2912	27	84	1.3	358	176	151
10	HOLL	806	26	64	44	60	4062	33	83	1.8	356	175	170
11	HOLL	802	24	65	45	64	4368	26	88	1.8	356	176	164
12	HOLL	788	24	69	39	80	4220	30	91	1.8	358	174	165
13	HOLL	802	23	60	41	74	4028	29	83	1.3	358	166	165
14	HOLL	809	22	65	40	64	4240	31	81	1.5	350	174	167
15	HOLL	722	31	68	40	139	4129	27	89	1.8	356	172	167
16	HOLL	796	19	68	36	81	3901	26	77	1.5	357	171	153
17	HOLL	775	26	68	41	90	4412	31	86	1.5	356	172	169
18	HOLL	783	21	65	40	91	4129	33	86	1.3	366	167	180
19	HOLL	807	27	59	42	65	4062	29	83	1.5	359	167	167
20	HOLL	747	27	70	43	113	4008	29	81	1.5	351	171	175
21	HOLL	788	26	69	40	77	4213	31	90	2.0	362	172	167
22	HOLL	789	23	66	48	74	4025	27	90	1.8	358	173	172
23	HONL	787	53	63	47	50	3450	31	76	1.3	359	168	184
24	HONL	798	58	65	44	35	3766	28	87	1.5	350	172	175
25	HONL	798	57	65	42	38	4011	25	78	1.3	355	172	178
26	HONL	781	56	68	43	52	3591	30	85	1.5	361	171	173
27	HONL	721	52	66	44	117	4361	32	90	1.3	359	172	171
28	HONL	798	50	67	41	44	4190	28	88	1.8	374	170	169
29	HONL	792	54	63	46	45	3847	32	88	1.5	357	168	172

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.

‡ = Days after 31 August.

§ = Score 1 (all plants erect) to 5 (all plants prostrate).

¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.

= Seed source is different from all other entries

Table C9. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	787	51	68	45	49	3729	30	84	1.0	358	169	166
31	HONL	800	51	64	43	42	3968	27	88	1.5	350	171	176
32	HONL	792	58	61	43	46	3998	30	89	1.3	358	166	162
33	HONL	804	55	66	41	34	3739	27	79	1.5	348	177	167
34	HONL	776	63	68	45	48	3675	26	83	1.5	364	173	162
35	HONL	795	58	68	41	38	4126	27	85	1.5	351	182	170
36	HONL	807	56	60	41	36	4072	27	84	1.3	361	171	170
37	HONL	748	51	63	46	92	4133	29	91	1.5	354	172	165
38	HONL	721	62	73	44	100	4085	27	81	1.5	348	180	167
39	NONL	219	71	100	50	560	3951	26	88	1.5	351	178	162
40	NONL	323	81	97	43	456	4186	28	76	1.3	356	177	177
41	NONL	258	80	96	50	516	4052	27	90	1.0	346	182	162
42	NONL	215	82	99	44	560	4291	29	88	1.3	343	178	181
43	NONL	218	66	101	45	570	3746	28	77	1.3	359	175	173
44	NONL	246	63	97	46	548	4055	26	90	1.3	353	175	173
45	NONL	229	70	104	44	553	3665	26	76	1.3	359	177	175
46	NONL	223	68	96	46	567	4170	29	91	1.0	354	175	166
47	NONL	201	72	98	46	583	4287	35	88	1.5	346	179	187
48	NONL	259	85	93	56	507	4032	31	88	1.5	353	171	172
49	NONL	215	69	105	49	562	3783	27	80	1.0	357	175	167
50	NONL	217	73	101	44	565	3894	28	81	1.5	354	176	183
51	NONL	223	87	92	49	549	4317	27	91	1.0	348	177	166
52	NONL	236	73	98	46	547	4546	31	93	1.5	347	178	171
53	NONL	210	87	104	43	556	4183	27	87	1.5	343	183	165
54	NONL	224	68	92	47	569	3615	28	82	1.0	352	178	159
SEM		22	2	2	1	20	186	1	3	0	2	1	2
LSD 0.05		64	7	5	4	56	528	3	9	0	6	4	6
LSD 0.01		85	9	7	6	75	704	5	12	1	9	5	8

Table C9. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
92M61	Check	212	88	96	37	567	3929	30	86	1.8	340	191	153
92Y80	Check	226	87	104	51	532	4079	24	81	1.3	364	184	169
93M11	Check	218	80	100	48	554	3704	26	73	1.0	344	196	156
93M42	Check	261	79	99	55	506	4036	31	96	1.8	361	163	167
93M11#	Check	230	78	97	49	546	4007	30	77	1.0	346	192	156
93Y11	Check	242	79	97	47	535	3713	28	74	1.0	360	181	180

Table C10. Mean performance of 16 high-oleate/low-linolenate, 16 high-oleate/normal-linolenate, and 16 normal-oleate/normal-linolenate lines from population 2 grown at Washington, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	785	22	63	42	88	4139	29	81	1.5	348	169	162
8	HOLL	779	25	66	47	83	4475	30	89	1.5	355	165	179
9	HOLL	800	22	60	50	68	2919	25	80	1.5	357	174	151
10	HOLL	812	23	64	42	59	4637	26	78	1.8	350	177	168
11	HOLL	735	26	71	44	124	4459	24	84	1.8	357	175	160
12	HOLL	787	23	69	45	76	4593	28	91	1.8	357	173	168
13	HOLL	796	23	60	41	80	4402	24	83	1.3	360	167	170
14	HOLL	810	22	65	42	61	4344	27	74	1.5	353	172	163
15	HOLL	789	25	65	39	82	4600	26	82	2.0	360	171	174
16	HOLL	795	20	68	37	80	4022	26	70	1.5	361	170	151
17	HOLL	776	25	69	44	86	4341	30	85	2.0	350	170	162
18	HOLL	790	20	63	44	83	4711	29	83	1.5	369	169	184
19	HOLL	802	25	60	41	72	4472	26	82	1.5	359	166	170
20	HOLL	796	23	67	44	70	4025	30	76	1.5	357	167	176
21	HOLL	777	26	70	43	84	4590	27	90	2.0	364	172	163
22	HOLL	785	22	67	46	80	4630	26	86	2.0	356	172	175
23	HONL	794	50	65	45	46	3964	26	73	1.3	361	164	183
24	HONL	800	56	65	42	37	4301	26	88	1.5	351	172	179
25	HONL	796	58	66	41	39	4334	25	87	1.5	361	170	188
26	HONL	786	53	66	44	51	4227	29	83	1.8	366	169	176
27	HONL	665	49	68	47	171	4671	30	87	2.0	358	169	167
28	HONL	789	54	66	47	44	4035	24	85	1.5	373	169	167
29	HONL	783	58	61	55	43	4496	33	83	2.0	363	163	175

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C10. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	780	53	69	47	51	4334	31	83	1.8	359	168	171
31	HONL	770	51	62	47	70	4509	27	85	1.5	357	171	182
32	HONL	793	59	59	43	46	4361	26	85	2.0	359	165	164
33	HONL	807	51	66	40	36	4116	25	78	1.5	352	175	169
34	HONL	777	64	68	43	48	4317	24	87	1.5	366	174	166
35	HONL	792	57	71	40	40	4388	26	81	1.5	356	184	169
36	HONL	812	53	59	42	34	4069	25	82	1.5	366	173	172
37	HONL	757	48	61	48	86	4149	25	82	1.5	353	176	166
38	HONL	779	59	70	41	51	4328	26	82	1.0	354	177	172
39	NONL	246	66	95	49	544	4146	24	84	1.5	350	180	163
40	NONL	311	83	97	42	467	4566	26	74	1.5	360	177	183
41	NONL	231	83	95	53	538	4344	26	80	1.0	351	178	167
42	NONL	222	77	96	48	557	4553	26	91	1.3	346	178	181
43	NONL	211	65	101	44	579	4586	26	80	1.5	360	177	179
44	NONL	224	63	99	49	565	3884	24	83	1.5	355	175	172
45	NONL	205	70	104	45	576	4341	26	77	1.3	362	178	182
46	NONL	229	65	93	52	561	4412	27	90	1.3	356	174	168
47	NONL	210	68	97	48	577	4923	32	82	1.5	352	177	193
48	NONL	233	83	94	59	531	4566	32	88	1.8	358	168	178
49	NONL	221	64	102	51	562	4196	25	80	1.3	360	174	164
50	NONL	220	71	97	48	564	4156	26	68	1.5	356	177	187
51	NONL	214	88	92	49	557	4439	26	84	1.5	353	174	161
52	NONL	205	73	98	47	577	4748	27	85	1.8	350	179	176
53	NONL	216	88	101	45	550	4718	26	87	1.5	348	181	172
54	NONL	295	62	90	50	503	4254	27	83	1.0	357	175	168
SEM		17	1	1	2	16	130	1	3	0	2	1	2
LSD 0.05		48	4	4	4	45	369	3	8	0	5	3	5
LSD 0.01		64	5	6	6	60	492	4	10	0	6	4	7

Table C10. Continued.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
92M61	Check	223	80	99	39	559	4069	25	75	1.5	343	194	157
92Y80	Check	405	67	88	47	393	4529	27	82	1.5	365	187	174
93M11	Check	230	77	96	53	544	4107	27	79	1.0	347	194	157
93M42	Check	229	81	105	54	531	4251	32	90	1.3	358	164	165
93M11#	Check	230	75	98	55	542	4389	26	76	1.0	347	197	159
93Y11	Check	224	83	102	43	548	4174	26	79	1.0	365	180	178

Table C11. Mean performance of 17 high-oleate/low-linolenate, 17 high-oleate/normal-linolenate, and 17 normal-oleate/normal-linolenate lines from population 3 grown at Atlantic, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	804	21	65	43	67	3974	25	99	2.0	360	184	195
8	HOLL	804	22	64	41	69	3460	27	90	2.0	361	174	184
9	HOLL	774	20	70	45	91	4361	27	103	2.0	361	179	200
10	HOLL	806	22	68	39	65	3510	25	89	1.8	361	187	183
11	HOLL	767	22	75	37	99	3991	24	101	2.0	361	182	199
12	HOLL	807	21	65	43	64	3406	23	96	2.5	359	190	209
13	HOLL	793	21	70	38	78	3958	28	101	3.3	370	179	195
14	HOLL	792	22	72	39	75	4119	24	107	1.5	365	187	200
15	HOLL	796	23	66	38	77	3964	28	104	2.3	364	177	208
16	HOLL	796	23	71	42	68	3679	25	90	1.8	363	181	190
17	HOLL	791	23	65	42	79	4496	26	108	1.5	360	177	193
18	HOLL	776	23	65	37	99	3810	24	97	1.8	358	181	180
19	HOLL	779	21	67	37	96	4512	26	106	2.0	370	174	214
20	HOLL	795	23	64	42	76	4170	29	116	2.8	373	178	219
21	HOLL	814	19	62	43	62	3588	26	101	2.5	363	184	199
22	HOLL	773	24	70	38	95	4079	26	101	2.5	366	178	201
23	HOLL	789	22	71	43	75	3315	22	88	1.8	379	179	181
24	HONL	784	59	70	41	46	3820	25	106	1.5	363	178	192
25	HONL	788	59	62	41	50	4795	28	106	2.3	371	172	207
26	HONL	805	55	66	35	39	4526	23	94	1.8	379	181	198
27	HONL	795	61	60	42	42	4573	28	107	2.3	364	174	201
28	HONL	762	67	68	32	71	3692	27	100	2.0	362	186	173
29	HONL	810	56	65	35	34	3944	23	104	1.5	373	178	193

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C11. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	805	57	65	37	36	4206	26	110	2.3	356	183	191
31	HONL	801	56	67	39	37	3897	26	103	2.3	359	187	178
32	HONL	796	60	62	39	43	3793	27	102	2.5	365	185	189
33	HONL	797	57	63	37	46	3901	25	96	1.5	360	185	197
34	HONL	786	57	65	37	55	2915	24	85	2.5	375	175	192
35	HONL	801	53	66	37	43	3329	27	97	2.3	363	174	190
36	HONL	788	50	62	41	59	3376	29	114	3.5	363	176	197
37	HONL	808	50	63	39	40	4314	24	104	1.5	367	182	205
38	HONL	798	49	66	43	44	4472	26	104	1.8	364	182	194
39	HONL	812	50	64	38	36	3978	26	100	2.0	364	182	190
40	HONL	766	68	67	37	62	4220	26	113	1.8	362	173	184
41	NONL	209	88	101	40	562	4260	27	98	1.8	351	186	190
42	NONL	210	79	101	39	571	4445	24	104	2.0	345	192	197
43	NONL	271	78	96	48	507	3816	27	99	1.8	352	184	174
44	NONL	225	84	104	46	541	3500	29	111	3.0	359	180	198
45	NONL	222	76	97	42	563	4449	25	102	2.3	363	175	211
46	NONL	204	84	103	38	571	4492	24	104	1.8	347	187	187
47	NONL	202	97	94	41	566	4509	30	103	2.8	347	176	178
48	NONL	246	70	101	41	542	4267	23	100	1.0	354	186	196
49	NONL	206	90	102	36	566	4442	23	104	2.0	352	187	195
50	NONL	221	72	99	44	564	3447	26	109	2.5	357	178	202
51	NONL	252	69	99	35	545	4274	24	97	1.8	352	184	194
52	NONL	222	85	100	42	551	4230	28	107	2.0	351	176	177
53	NONL	204	71	107	41	577	4758	26	103	2.0	356	184	187
54	NONL	227	85	96	42	550	4096	28	110	2.5	350	188	191
55	NONL	253	84	98	44	521	4048	27	106	1.8	354	187	187
56	NONL	250	78	99	39	534	4422	29	100	2.5	358	179	199
57	NONL	231	70	98	39	562	4365	26	107	2.3	351	191	206

Table C11. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
SEM		13	2	1	1	12	156	1	3	0	3	1	4
LSD 0.05		38	6	4	3	33	443	2	8	1	8	3	10
LSD 0.01		50	8	5	4	44	591	3	10	1	10	5	13
92M61	Check	211	86	100	37	566	4410	25	100	1.5	334	194	165
92Y80	Check	308	74	102	41	475	4498	25	99	1.8	356	190	184
93M11	Check	215	86	99	42	558	4597	25	97	1.0	338	199	177
93M42	Check	227	82	109	50	532	3873	28	113	2.0	352	178	170
93Y11#	Check	239	85	97	42	537	4036	26	100	1.5	349	191	190
93Y11	Check	227	83	100	43	547	4311	26	97	1.3	350	188	189

Table C12. Mean performance of 17 high-oleate/low-linolenate, 17 high-oleate/normal-linolenate, and 17 normal-oleate/normal-linolenate lines from population 3 grown at Hedrick, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	806	21	63	45	65	3497	25	86	1.0	347	181	165
8	HOLL	766	25	64	46	99	3221	27	83	1.5	349	173	158
9	HOLL	785	23	67	48	77	4146	30	87	1.5	361	172	187
10	HOLL	749	28	69	44	110	3547	26	75	1.0	357	183	169
11	HOLL	780	22	72	42	84	3759	26	85	1.0	357	179	177
12	HOLL	806	20	64	46	64	3423	26	86	1.5	353	184	187
13	HOLL	798	21	67	41	73	4180	28	89	1.8	347	182	177
14	HOLL	785	27	68	45	75	3864	25	93	1.5	361	183	190
15	HOLL	752	28	67	42	111	4280	32	94	1.5	353	173	194
16	HOLL	801	28	67	44	60	3423	26	86	1.0	355	176	171
17	HOLL	798	23	61	49	69	3497	29	87	1.0	342	171	172
18	HOLL	774	28	63	40	95	3588	29	79	1.0	366	180	172
19	HOLL	788	22	65	39	86	4005	26	93	1.5	354	177	190
20	HOLL	803	22	62	43	70	3988	30	97	1.5	355	177	198
21	HOLL	817	19	60	46	58	3315	27	90	1.5	349	182	182
22	HOLL	803	25	65	40	67	3302	24	89	1.3	348	181	166
23	HOLL	789	23	67	48	73	3046	25	75	1.0	366	176	160
24	HONL	798	55	64	44	39	4143	25	88	1.0	351	179	179
25	HONL	792	57	61	42	48	4328	34	93	1.5	363	170	189
26	HONL	790	53	65	39	53	3679	27	80	1.3	369	177	180
27	HONL	802	58	59	40	41	3726	31	87	1.5	359	168	174
28	HONL	788	58	63	38	53	3800	29	82	1.5	363	183	161
29	HONL	807	57	62	41	33	3726	29	87	1.0	371	172	177

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C12. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	803	58	62	43	34	3988	27	90	1.5	354	180	170
31	HONL	813	55	60	43	29	4257	28	90	1.3	356	184	169
32	HONL	806	47	62	40	45	3860	29	90	1.3	358	183	178
33	HONL	808	51	60	40	41	3904	27	77	1.3	360	182	185
34	HONL	798	51	64	37	50	3393	27	79	1.3	367	172	177
35	HONL	810	49	62	41	38	3662	30	83	1.5	350	175	178
36	HONL	774	53	65	42	66	3595	32	100	2.0	354	178	181
37	HONL	804	50	64	41	41	4062	26	95	1.5	355	180	186
38	HONL	780	48	65	46	61	4096	26	82	1.0	365	179	179
39	HONL	814	47	62	44	33	4146	27	87	1.5	358	182	173
40	HONL	789	62	63	40	46	3964	28	97	1.0	359	168	174
41	NONL	229	88	101	44	538	3796	29	83	1.5	352	184	169
42	NONL	218	77	98	42	565	3904	27	84	1.3	343	191	175
43	NONL	258	76	99	55	512	3776	29	87	1.5	358	179	167
44	NONL	246	84	101	52	517	3689	32	90	1.5	358	178	179
45	NONL	220	79	94	44	563	3907	27	90	1.5	357	178	184
46	NONL	216	80	96	43	565	3840	26	86	1.0	348	185	166
47	NONL	231	91	92	43	543	4096	32	85	1.8	344	177	153
48	NONL	233	65	99	47	556	3685	25	80	1.0	360	183	180
49	NONL	211	90	98	39	562	3786	25	86	1.5	350	187	166
50	NONL	248	69	94	48	541	3870	26	87	1.5	349	180	175
51	NONL	209	71	96	38	586	4011	25	85	1.5	356	180	179
52	NONL	271	62	97	46	524	4260	29	94	1.3	354	174	165
53	NONL	218	68	99	48	567	3514	28	85	1.0	354	181	167
54	NONL	220	89	97	40	554	3699	30	101	1.0	350	183	177
55	NONL	267	83	92	50	508	3894	27	90	1.3	354	183	176
56	NONL	285	70	95	43	507	4015	28	87	1.5	352	178	172
57	NONL	260	63	94	41	542	3870	27	86	1.3	350	187	172

Table C12. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
SEM		18	2	2	1	16	154	1	3	0	3	2	3
LSD 0.05		52	6	4	4	45	437	4	7	0	10	5	10
LSD 0.01		69	8	6	6	60	582	5	10	1	13	6	13
92M61	Check	213	87	96	37	567	3607	22	85	1.3	341	190	148
92Y80	Check	271	79	102	45	503	4145	23	84	1.5	359	189	172
93M11	Check	220	79	96	49	556	3670	28	84	1.0	347	191	152
93M42	Check	241	83	105	61	510	3723	34	93	1.3	358	164	161
93Y11#	Check	291	76	95	47	491	3940	30	80	1.3	361	181	176
93Y11	Check	240	85	98	44	533	3875	28	81	1.0	359	181	180

Table C13. Mean performance of 17 high-oleate/low-linolenate, 17 high-oleate/normal-linolenate, and 17 normal-oleate/normal-linolenate lines from population 3 grown at Washington, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	803	21	64	47	65	4398	26	80	1.5	361	177	178
8	HOLL	802	23	63	46	66	4015	27	80	1.5	360	168	168
9	HOLL	781	20	70	46	83	4512	30	94	1.5	360	170	187
10	HOLL	816	20	63	43	58	3827	27	70	1.5	363	178	173
11	HOLL	777	24	71	42	86	4257	25	82	1.5	367	176	184
12	HOLL	790	22	66	45	77	4001	25	86	1.5	365	173	183
13	HOLL	701	22	73	45	159	4418	26	94	2.0	359	180	179
14	HOLL	790	22	71	42	75	4196	25	88	1.0	367	182	190
15	HOLL	788	25	66	39	82	4277	33	92	1.5	365	170	194
16	HOLL	786	26	71	49	68	3793	26	88	1.5	361	171	175
17	HOLL	804	23	63	48	62	4728	32	90	1.0	361	167	182
18	HOLL	805	22	62	44	67	4391	27	76	1.0	368	177	177
19	HOLL	798	20	65	40	77	4627	32	88	1.5	379	169	198
20	HOLL	791	24	60	50	75	4257	32	96	1.5	363	167	200
21	HOLL	810	20	60	49	61	3988	28	90	1.5	367	172	194
22	HOLL	801	24	67	39	69	4465	24	84	1.0	373	171	181
23	HOLL	786	23	72	47	72	3860	24	78	1.5	370	175	170
24	HONL	784	56	62	42	56	4479	26	92	1.0	367	174	178
25	HONL	793	58	60	43	46	4586	33	90	2.0	374	163	192
26	HONL	811	53	65	39	32	4136	25	86	1.5	372	174	183
27	HONL	794	61	59	44	42	4546	30	90	1.5	365	167	174
28	HONL	765	65	65	38	67	4479	31	86	1.5	372	178	169
29	HONL	807	56	63	39	35	4001	25	82	1.0	376	172	177

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C13. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HONL	809	54	63	44	30	4385	25	94	1.5	361	178	176
31	HONL	810	55	62	42	31	4519	26	90	1.5	362	181	169
32	HONL	808	56	59	41	36	4331	26	86	2.0	358	179	176
33	HONL	798	59	59	40	44	4270	26	78	1.5	360	180	183
34	HONL	794	54	63	41	48	3531	24	78	1.5	374	172	178
35	HONL	694	56	68	45	137	4082	30	84	1.0	363	167	178
36	HONL	786	54	63	39	58	4472	34	100	2.5	364	171	184
37	HONL	797	54	63	44	42	4122	26	84	1.5	360	178	189
38	HONL	793	50	65	48	44	4391	25	82	1.0	373	176	179
39	HONL	814	48	59	48	31	4270	25	86	1.5	365	178	172
40	HONL	668	67	67	44	154	4210	27	84	1.5	367	164	173
41	NONL	223	85	99	45	548	4338	26	90	1.5	356	184	175
42	NONL	212	79	100	40	569	4533	25	90	1.0	352	190	182
43	NONL	241	79	95	62	523	4062	31	84	1.5	363	175	165
44	NONL	228	86	98	53	535	4311	33	94	1.5	366	174	184
45	NONL	215	72	95	46	572	4264	26	80	1.5	362	176	185
46	NONL	217	76	95	47	565	4412	25	84	1.5	355	183	177
47	NONL	213	91	93	47	556	4923	34	86	3.0	357	170	158
48	NONL	230	63	98	52	557	4183	24	82	1.0	364	182	190
49	NONL	206	89	102	36	567	4714	25	90	1.5	359	180	166
50	NONL	206	73	101	45	575	4297	25	90	2.0	363	173	184
51	NONL	224	60	95	40	581	3934	24	78	1.5	358	185	177
52	NONL	235	79	92	48	546	4257	27	86	2.0	360	170	162
53	NONL	217	64	102	44	573	4546	26	90	1.5	360	180	172
54	NONL	231	87	90	46	546	4203	33	102	1.5	366	174	184
55	NONL	226	82	95	53	544	4452	30	90	1.0	364	178	181
56	NONL	291	73	93	39	504	4714	27	82	2.0	359	173	168
57	NONL	237	68	95	42	558	4344	27	88	1.0	362	181	187

Table C13. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
SEM													
LSD 0.05													
LSD 0.01													
92M61	Check	214	85	98	39	564	4196	25	84	1.5	342	194	154
92Y80	Check	219	86	107	43	545	4120	26	80	1.5	363	187	174
93M11	Check	236	75	90	60	539	4076	26	80	1.0	351	192	153
93M42	Check	263	75	93	68	501	4549	34	94	1.5	363	162	166
93Y11#	Check	241	79	93	47	540	4338	27	82	1.0	366	179	178
93Y11	Check	252	80	95	50	523	4071	26	82	1.0	365	179	179

Table C14. Mean performance of 24 high-oleate/low-linolenate, 24 high-oleate/normal-linolenate, and 24 normal-oleate/normal-linolenate lines from population 4 grown at Atlantic, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	803	22	61	42	72	4627	26	102	1.8	359	178	214
8	HOLL	805	22	65	43	65	3215	22	97	1.5	364	182	185
9	HOLL	800	25	68	44	63	3890	25	104	1.5	347	179	193
10	HOLL	814	25	64	37	60	4344	24	95	1.3	349	184	183
11	HOLL	733	24	69	44	130	3793	26	103	2.0	366	173	196
12	HOLL	793	24	61	42	80	3860	26	101	2.3	346	183	191
13	HOLL	787	22	66	38	87	3359	24	103	2.0	354	183	179
14	HOLL	779	25	65	40	91	3719	26	104	2.0	358	178	201
15	HOLL	781	29	66	49	75	4099	27	108	2.0	354	177	195
16	HOLL	808	22	66	40	64	4465	26	104	1.8	371	175	204
17	HOLL	801	24	64	39	72	3995	26	93	1.5	352	184	175
18	HOLL	789	22	67	38	84	4190	25	94	1.8	352	184	193
19	HOLL	796	24	61	36	83	3880	22	94	1.5	347	183	171
20	HOLL	790	24	70	43	73	3732	27	108	1.8	358	180	197
21	HOLL	814	20	63	38	65	4032	24	96	2.3	356	178	189
22	HOLL	813	25	65	35	62	4032	25	97	1.5	358	181	184
23	HOLL	789	24	66	46	75	4112	26	106	1.5	357	174	202
24	HOLL	801	24	61	41	73	4462	25	93	1.5	360	179	215
25	HOLL	785	21	73	35	86	3823	23	100	1.5	359	178	209
26	HOLL	760	25	68	41	106	3467	23	103	1.8	365	179	181
27	HOLL	795	26	65	40	74	3917	25	104	2.0	359	179	192
28	HOLL	801	24	64	39	72	4186	25	105	1.5	361	177	195
29	HOLL	775	21	67	41	96	3917	26	101	1.5	356	177	199

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C14. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HOLL	802	22	65	38	73	4381	23	93	1.3	355	185	188
31	HONL	807	59	62	39	33	4439	24	95	1.5	358	179	200
32	HONL	800	53	61	43	43	4391	27	112	2.0	353	181	212
33	HONL	812	55	60	40	33	3272	23	93	1.5	360	182	194
34	HONL	785	57	65	37	56	4186	26	108	2.0	362	176	211
35	HONL	796	61	66	39	38	3769	25	98	2.0	357	180	201
36	HONL	776	64	69	39	52	3581	25	98	2.0	351	184	198
37	HONL	799	52	63	39	47	4233	23	91	1.8	359	184	192
38	HONL	796	59	67	43	35	4297	26	107	2.0	358	180	202
39	HONL	783	58	72	37	50	3806	24	96	1.3	358	183	213
40	HONL	801	53	58	43	45	4486	26	109	1.5	353	181	211
41	HONL	807	50	67	40	36	4580	25	103	2.3	366	183	203
42	HONL	796	58	68	38	40	3837	23	98	2.0	368	183	197
43	HONL	789	64	63	36	48	4462	26	108	2.3	363	177	202
44	HONL	798	62	64	36	40	4206	25	90	1.5	353	183	198
45	HONL	760	56	66	39	79	4475	27	100	2.3	368	174	204
46	HONL	788	60	69	37	46	3336	20	97	1.5	358	180	188
47	HONL	788	57	65	46	44	4354	30	110	2.3	365	173	214
48	HONL	786	64	69	41	40	3997	25	104	1.8	366	177	204
49	HONL	775	61	67	38	59	4395	25	102	1.8	359	179	208
50	HONL	782	66	61	42	49	4203	27	101	2.3	359	179	201
51	HONL	801	58	66	39	36	3877	24	94	1.8	362	181	200
52	HONL	709	58	72	45	116	4237	26	104	1.8	362	175	186
53	HONL	782	61	67	42	48	4358	28	110	2.5	368	171	220
54	HONL	797	52	69	39	43	4032	26	102	1.5	355	183	201
55	NONL	248	67	101	45	539	4536	25	102	1.5	347	187	208
56	NONL	208	69	97	40	586	3806	28	116	2.5	349	186	185
57	NONL	228	73	100	50	549	4311	26	99	2.0	357	181	205
58	NONL	239	45	97	40	579	3985	25	101	1.5	343	186	203
59	NONL	234	72	94	41	559	4351	26	103	2.0	357	180	211

Table C14. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
60	NONL	234	70	94	39	563	3827	24	102	1.8	342	187	188
61	NONL	206	83	103	40	568	4072	26	109	1.8	348	184	188
62	NONL	200	71	94	37	598	4317	27	109	2.8	354	182	198
63	NONL	213	69	94	48	576	4502	31	113	2.8	340	188	207
64	NONL	232	78	95	44	551	3998	26	99	2.5	353	189	198
65	NONL	221	79	101	42	557	4644	27	110	2.0	350	184	220
66	NONL	234	83	100	44	539	4291	24	103	2.0	362	181	219
67	NONL	223	75	96	50	556	4267	27	104	2.0	352	180	210
68	NONL	208	86	97	43	566	4449	26	103	2.3	352	187	219
69	NONL	208	77	97	40	578	4260	27	109	2.5	360	180	207
70	NONL	207	70	93	45	585	3961	28	104	2.3	349	187	181
71	NONL	202	85	94	45	574	4149	25	108	2.0	351	189	208
72	NONL	204	68	96	37	595	4597	23	101	1.3	343	190	186
73	NONL	250	71	96	46	537	4415	25	104	1.8	345	184	209
74	NONL	218	69	96	47	570	4546	26	102	1.5	351	184	207
75	NONL	260	72	94	54	520	4667	27	106	2.3	354	181	214
76	NONL	205	77	101	43	574	4096	23	91	1.8	345	191	184
77	NONL	232	78	102	43	545	4230	29	108	1.8	350	182	192
78	NONL	218	81	95	43	563	4630	25	108	1.8	341	188	194
SEM		15	2	1	1	14	167	1	3	0	3	1	5
LSD 0.05		43	6	3	4	40	471	2	8	1	9	4	13
LSD 0.01		57	7	4	5	53	626	3	10	1	12	4	17
92M61	Check	201	86	99	34	580	4038	25	95	1.5	334	195	164
92Y80	Check	224	89	105	43	539	4078	25	96	1.5	358	189	188
93M11	Check	224	82	99	45	550	4374	25	94	1.0	338	199	173
93M42	Check	246	80	106	51	517	3798	27	109	1.8	348	178	160
93Y20#	Check	207	83	93	38	579	4446	27	105	1.5	338	192	181
93M61	Check	214	87	100	38	561	4567	28	97	1.3	340	184	178

Table C15. Mean performance of 24 high-oleate/low-linolenate, 24 high-oleate/normal-linolenate, and 24 normal-oleate/normal-linolenate lines from population 4 grown at Hedrick, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	804	22	60	44	70	4321	28	91	1.5	354	173	191
8	HOLL	794	21	63	49	73	3201	26	89	1.8	356	177	166
9	HOLL	802	25	65	47	61	4129	29	96	1.3	341	173	183
10	HOLL	813	25	61	41	60	4344	26	87	1.0	349	182	166
11	HOLL	780	26	66	44	84	3776	28	94	1.8	359	173	182
12	HOLL	797	22	60	43	78	3833	28	91	1.8	342	179	176
13	HOLL	797	23	64	40	76	3299	26	84	1.8	350	184	164
14	HOLL	776	26	63	46	89	3776	28	91	1.5	348	177	186
15	HOLL	763	26	67	50	94	4028	28	100	1.8	356	173	185
16	HOLL	795	23	66	47	69	4264	27	91	1.8	354	174	179
17	HOLL	807	22	61	44	66	3907	31	87	1.5	353	175	164
18	HOLL	794	23	65	44	74	4011	26	86	1.8	346	180	171
19	HOLL	791	26	59	38	86	3598	29	84	1.3	339	180	166
20	HOLL	794	22	69	46	69	3463	29	94	1.5	344	176	177
21	HOLL	775	27	64	44	90	4035	24	94	1.5	345	180	161
22	HOLL	814	23	66	33	64	3887	25	94	1.5	350	180	163
23	HOLL	790	23	64	49	74	3998	27	96	1.5	354	172	184
24	HOLL	807	23	59	47	64	4200	26	88	1.5	358	175	192
25	HOLL	791	22	68	39	80	3874	24	90	1.5	358	175	189
26	HOLL	800	21	64	44	71	3598	25	97	2.0	361	178	162
27	HOLL	781	25	64	44	86	4240	26	96	1.5	352	176	173
28	HOLL	736	29	66	44	125	4203	26	94	1.5	350	176	180
29	HOLL	756	25	63	51	105	3927	29	92	1.3	343	172	177

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C15. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HOLL	813	24	62	41	60	3732	25	84	1.3	344	183	161
31	HONL	793	64	60	39	44	3524	27	85	1.0	347	178	167
32	HONL	797	53	61	47	42	4096	32	102	2.0	350	175	192
33	HONL	804	56	59	46	35	3272	26	84	1.5	347	183	175
34	HONL	808	57	62	39	34	3931	27	98	1.8	345	179	183
35	HONL	793	62	64	41	40	3840	28	96	1.3	346	179	173
36	HONL	782	59	68	41	50	3692	28	87	1.3	350	179	183
37	HONL	750	56	64	43	87	3581	24	84	1.5	343	187	167
38	HONL	797	58	67	43	35	4159	29	95	1.3	348	175	177
39	HONL	787	58	67	43	45	3534	26	87	1.5	350	181	193
40	HONL	793	56	58	47	46	4358	28	96	1.5	345	179	185
41	HONL	775	52	67	40	66	4287	27	95	1.5	350	178	177
42	HONL	794	58	66	40	42	3638	25	85	1.5	353	181	170
43	HONL	779	64	63	38	56	3786	28	100	1.5	350	176	173
44	HONL	802	58	63	40	37	3736	27	87	1.5	349	178	178
45	HONL	802	53	59	42	44	4291	28	96	1.5	356	171	175
46	HONL	782	62	65	40	51	3732	24	93	1.5	354	178	178
47	HONL	789	54	64	48	45	3901	30	99	2.0	354	172	186
48	HONL	750	63	69	45	73	4035	27	90	1.3	357	173	182
49	HONL	796	58	66	37	43	3991	28	96	1.5	350	176	184
50	HONL	780	64	59	46	51	3937	29	93	1.5	347	176	178
51	HONL	815	50	62	39	34	3773	25	82	1.5	356	183	182
52	HONL	740	63	69	49	79	4085	27	98	1.3	357	172	166
53	HONL	713	60	69	48	110	4176	28	106	1.5	356	172	183
54	HONL	734	53	69	42	102	3934	27	93	1.0	355	177	175
55	NONL	219	68	100	48	565	4321	27	89	1.0	349	185	184
56	NONL	223	65	95	47	570	3564	29	101	1.5	341	186	167
57	NONL	302	72	94	52	480	4035	28	90	1.5	351	180	181
58	NONL	257	43	96	40	564	3521	28	86	1.3	341	183	175
59	NONL	203	75	96	42	584	4247	26	92	1.5	350	180	173

Table C15. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
60	NONL	217	70	93	44	576	3568	25	89	1.5	339	188	172
61	NONL	211	85	102	41	561	4035	28	99	1.3	348	180	172
62	NONL	213	69	92	41	585	4254	29	100	1.5	350	181	171
63	NONL	226	69	92	52	561	4210	32	98	1.8	343	180	192
64	NONL	248	73	93	43	543	3672	27	81	1.5	355	185	169
65	NONL	255	77	95	46	527	4035	28	98	1.5	347	182	189
66	NONL	211	86	101	42	560	4109	24	95	1.5	348	184	183
67	NONL	240	75	96	50	539	4287	30	95	1.0	351	178	180
68	NONL	212	85	93	45	565	4287	28	97	1.3	349	185	189
69	NONL	216	76	94	45	569	4170	27	95	1.5	355	179	177
70	NONL	214	69	91	47	579	3685	29	96	1.8	346	186	154
71	NONL	252	84	93	50	521	4243	27	91	1.5	349	185	188
72	NONL	214	66	89	40	591	3944	27	94	1.0	343	188	165
73	NONL	262	73	93	44	528	4082	29	92	1.0	347	180	188
74	NONL	219	68	97	49	567	3796	28	94	1.3	348	183	173
75	NONL	258	70	97	54	521	3991	30	100	1.5	353	175	188
76	NONL	210	77	96	46	571	3675	26	84	1.5	345	185	165
77	NONL	230	73	100	45	552	4129	32	94	1.3	356	179	175
78	NONL	219	82	91	48	560	4183	27	97	1.0	336	187	168
SEM		17	2	1	2	15	206	1	3	0	3	1	3
LSD 0.05		48	4	4	5	44	581	3	10	0	9	4	9
LSD 0.01		64	6	6	6	58	771	3	10	1	12	5	12
92M61	Check	229	81	96	39	555	3567	26	83	1.5	335	193	146
92Y80	Check	210	87	112	43	548	3733	27	84	1.3	357	188	167
93M11	Check	225	79	96	46	554	3707	25	82	1.0	345	195	154
93M42	Check	267	78	102	61	492	3732	37	94	1.3	354	166	159
93Y20#	Check	214	87	94	39	566	4416	24	93	1.3	338	187	166
93M61	Check	223	87	97	40	553	4124	31	91	1.5	343	179	159

Table C16. Mean performance of 24 high-oleate/low-linolenate, 24 high-oleate/normal-linolenate, and 24 normal-oleate/normal-linolenate lines from population 4 grown at Washington, IA in 2009.

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity‡	Height	Lodging§	Protein¶	Oil¶	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
7	HOLL	806	22	60	43	69	4254	33	87	2.3	362	169	205
8	HOLL	801	21	63	46	69	3574	28	82	2.0	364	175	179
9	HOLL	801	24	67	49	59	4025	31	81	1.5	359	167	197
10	HOLL	808	24	63	39	66	4560	28	76	1.5	354	179	180
11	HOLL	766	26	65	45	98	4331	29	85	2.5	364	171	199
12	HOLL	799	24	59	47	71	3816	30	79	2.3	351	173	189
13	HOLL	794	22	63	45	76	3130	28	84	2.5	370	173	194
14	HOLL	782	24	63	48	83	3628	30	79	2.8	360	173	202
15	HOLL	731	30	67	53	119	3231	31	81	3.0	357	168	191
16	HOLL	793	24	63	51	69	4190	28	84	2.5	364	170	196
17	HOLL	802	22	64	44	68	4116	32	79	1.8	361	174	173
18	HOLL	792	22	65	42	79	3931	28	76	2.3	356	177	183
19	HOLL	775	25	61	41	98	3305	28	76	2.3	353	180	182
20	HOLL	793	23	69	46	69	3870	32	91	1.8	357	171	194
21	HOLL	803	22	61	43	71	4351	27	83	2.8	359	176	181
22	HOLL	825	22	61	36	56	3574	26	77	1.8	358	181	178
23	HOLL	787	24	63	52	74	4267	30	86	1.8	365	167	192
24	HOLL	808	23	60	46	63	4425	28	85	1.8	370	170	210
25	HOLL	779	22	70	38	91	3864	26	79	2.0	356	176	197
26	HOLL	741	29	65	44	121	3453	28	85	2.3	363	177	171
27	HOLL	796	23	64	47	70	3790	29	84	1.8	364	171	184
28	HOLL	732	25	67	47	129	4059	30	80	2.3	364	172	194
29	HOLL	789	22	63	50	76	3790	31	85	1.8	361	168	193

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Days after 31 August.
§ = Score 1 (all plants erect) to 5 (all plants prostrate).
¶ = Protein and oil concentration based on a moisture basis of 130 g kg^{-1}.
# = Seed source is different from all other entries

Table C16. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
30	HOLL	811	21	62	39	67	4354	26	78	2.0	355	181	174
31	HONL	792	62	63	41	42	3827	28	79	1.5	358	176	187
32	HONL	801	52	60	46	41	4200	31	93	2.3	361	174	202
33	HONL	798	58	60	48	36	3668	27	78	1.8	359	177	190
34	HONL	809	55	61	39	36	4025	28	89	2.8	359	174	205
35	HONL	806	54	63	41	36	4166	31	83	1.8	360	177	193
36	HONL	762	58	68	43	69	3867	30	80	1.8	357	176	198
37	HONL	806	51	61	42	40	4122	26	75	2.0	351	183	183
38	HONL	795	60	65	45	35	3894	32	89	2.0	365	171	194
39	HONL	779	58	69	45	49	3504	27	73	1.8	366	177	211
40	HONL	807	50	57	45	41	4519	32	91	2.0	352	174	196
41	HONL	808	49	64	42	37	4106	30	81	1.8	363	172	188
42	HONL	789	60	67	40	44	3756	26	84	2.0	358	180	183
43	HONL	789	61	63	40	47	3484	31	84	2.0	365	170	192
44	HONL	803	57	62	41	37	4143	31	78	1.8	353	176	193
45	HONL	805	52	60	43	40	4378	31	83	2.3	367	167	193
46	HONL	772	62	68	39	59	3480	26	79	2.8	350	179	186
47	HONL	785	55	64	49	47	4075	36	88	2.5	368	166	200
48	HONL	781	62	69	46	42	4287	30	82	2.5	366	173	199
49	HONL	806	55	64	37	38	4425	31	84	2.3	361	174	193
50	HONL	783	65	59	46	47	4267	32	82	2.0	361	170	196
51	HONL	812	52	63	39	34	4170	26	73	1.8	361	182	193
52	HONL	736	63	69	54	78	3231	31	85	2.0	369	166	181
53	HONL	775	62	67	42	54	4136	39	92	2.0	369	168	205
54	HONL	794	52	68	45	41	4210	32	82	1.5	358	176	191
55	NONL	213	65	100	49	573	3406	28	81	2.5	359	182	200
56	NONL	223	66	93	44	574	3521	32	90	2.0	357	179	189
57	NONL	273	65	95	51	516	4119	29	81	1.8	358	178	189
58	NONL	226	42	95	42	595	3914	30	81	1.5	352	179	194
59	NONL	216	68	91	46	579	4462	28	79	2.0	349	181	194

Table C16. Continued

Entry	Class†	Oleate	Linolenate	Palmitate	Stearate	Linoleate	Yield	Maturity	Height	Lodging	Protein	Oil	Seed weight
		g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	days	cm	score	g kg^{-1}	g kg^{-1}	mg sd^{-1}
60	NONL	219	67	91	45	578	3416	27	74	2.0	346	186	179
61	NONL	218	81	98	43	560	4230	32	90	2.0	352	179	180
62	NONL	205	69	91	37	598	4183	30	88	2.0	361	175	190
63	NONL	232	66	91	49	562	3598	37	91	3.8	356	175	207
64	NONL	246	71	94	44	545	4170	31	79	1.8	357	186	181
65	NONL	230	76	97	47	550	4159	31	89	2.3	356	179	205
66	NONL	218	81	97	43	561	4170	27	84	2.0	358	181	204
67	NONL	241	68	91	53	547	4136	31	85	2.0	358	173	198
68	NONL	230	82	95	43	550	4183	29	83	2.0	355	183	198
69	NONL	223	75	92	43	567	4395	28	92	2.0	367	173	194
70	NONL	217	66	88	50	579	4277	32	90	2.3	353	184	171
71	NONL	216	80	95	49	560	4277	28	85	1.8	353	186	201
72	NONL	214	65	89	43	589	4015	28	81	1.5	349	187	173
73	NONL	278	68	87	49	518	4180	30	82	2.0	358	177	199
74	NONL	213	66	96	48	577	4381	28	83	2.0	359	180	199
75	NONL	307	72	90	53	478	4334	31	94	2.3	363	171	201
76	NONL	218	71	94	48	569	4116	27	85	2.0	345	189	178
77	NONL	204	78	102	43	573	4805	41	87	2.8	363	175	184
78	NONL	213	83	93	45	566	4365	30	91	2.3	345	185	183
SEM		15	2	1	2	13	173	1	3	0	2	1	2
LSD 0.05		41	5	4	6	45	487	2	8	1	6	4	6
LSD 0.01		55	6	7	7	49	646	3	11	1	8	5	8
92M61	Check	267	78	95	38	522	4160	29	73	1.5	344	194	159
92Y80	Check	220	87	106	45	542	4409	32	76	1.8	361	186	178
93M11	Check	226	75	98	48	553	3977	32	69	1.3	345	195	161
93M42	Check	248	80	101	60	511	4232	40	92	2.0	363	162	170
93Y20#	Check	211	84	92	38	575	4265	33	82	1.8	341	186	174
93M61	Check	216	83	98	42	561	4110	40	79	1.5	346	179	173

Table C17. Mean performance of high-oleate/low-linolenate, high-oleate/normal-linolenate, and normal-oleate/normal-linolenate lines from the four populations grown at Princeton, IL in 2009.

Population 1			Population 2			Population 3			Population 4		
Entry	Class†	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}
7	HOLL	3840	7	HOLL	3561	7	HOLL	3749	7	HOLL	3601
8	HOLL	3601	8	HOLL	3907	8	HOLL	3480	8	HOLL	2861
9	HOLL	3685	9	HOLL	2781	9	HOLL	3712	9	HOLL	3806
10	HOLL	4045	10	HOLL	3164	10	HOLL	3480	10	HOLL	3211
11	HOLL	3268	11	HOLL	3403	11	HOLL	3948	11	HOLL	3695
12	HOLL	3043	12	HOLL	3931	12	HOLL	3107	12	HOLL	3665
13	HOLL	3598	13	HOLL	3473	13	HOLL	3719	13	HOLL	3278
14	HOLL	3241	14	HOLL	3379	14	HOLL	3581	14	HOLL	3668
15	HOLL	3877	15	HOLL	3336	15	HOLL	3386	15	HOLL	3823
16	HOLL	3941	16	HOLL	3396	16	HOLL	3568	16	HOLL	3595
17	HOLL	3884	17	HOLL	3605	17	HOLL	3985	17	HOLL	3655
18	HOLL	3695	18	HOLL	3383	18	HOLL	3773	18	HOLL	3853
19	HOLL	3874	19	HOLL	3800	19	HOLL	3830	19	HOLL	3719
20	HOLL	3837	20	HOLL	3194	20	HOLL	3974	20	HOLL	3719
21	HONL	3467	21	HOLL	3668	21	HOLL	3726	21	HOLL	3107
22	HONL	3584	22	HOLL	3406	22	HOLL	3352	22	HOLL	3235
23	HONL	3403	23	HONL	3083	23	HOLL	3198	23	HOLL	3732
24	HONL	3816	24	HONL	3679	24	HONL	3776	24	HOLL	3618
25	HONL	3954	25	HONL	3766	25	HONL	3749	25	HOLL	3726
26	HONL	3568	26	HONL	3568	26	HONL	3813	26	HOLL	3278
27	HONL	3827	27	HONL	3534	27	HONL	3090	27	HOLL	3551
28	HONL	3100	28	HONL	3030	28	HONL	3675	28	HOLL	3376
29	HONL	3473	29	HONL	3971	29	HONL	3911	29	HOLL	3605
30	HONL	3870	30	HONL	3598	30	HONL	3790	30	HOLL	3840
31	HONL	3638	31	HONL	3618	31	HONL	3800	31	HONL	3524
32	HONL	3880	32	HONL	3211	32	HONL	3558	32	HONL	3510

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.
‡ = Seed source is different from all other entries

Table C17. Continued.

Population 1			Population 2			Population 3			Population 4		
Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}
33	HONL	3510	33	HONL	3416	33	HONL	3924	33	HONL	3147
34	HONL	3141	34	HONL	4143	34	HONL	2878	34	HONL	3739
35	NONL	3638	35	HONL	4099	35	HONL	3537	35	HONL	4045
36	NONL	3803	36	HONL	3833	36	HONL	2841	36	HONL	3272
37	NONL	3766	37	HONL	3860	37	HONL	3420	37	HONL	3682
38	NONL	3366	38	HONL	4035	38	HONL	3995	38	HONL	3763
39	NONL	3426	39	NONL	3773	39	HONL	3971	39	HONL	3356
40	NONL	3712	40	NONL	3568	40	HONL	3507	40	HONL	3981
41	NONL	3840	41	NONL	3477	41	NONL	3494	41	HONL	3278
42	NONL	3716	42	NONL	4129	42	NONL	3759	42	HONL	3753
43	NONL	3726	43	NONL	3547	43	NONL	3463	43	HONL	3383
44	NONL	3497	44	NONL	3601	44	NONL	2898	44	HONL	3974
45	NONL	3813	45	NONL	3558	45	NONL	3857	45	HONL	3736
46	NONL	3578	46	NONL	3948	46	NONL	4015	46	HONL	2835
47	NONL	3638	47	NONL	3638	47	NONL	3739	47	HONL	3558
48	NONL	4092	48	NONL	3860	48	NONL	4048	48	HONL	3803
			49	NONL	3685	49	NONL	3668	49	HONL	3147
			50	NONL	3238	50	NONL	3584	50	HONL	3901
			51	NONL	3991	51	NONL	3584	51	HONL	3598
			52	NONL	3867	52	NONL	3628	52	HONL	3618
			53	NONL	3578	53	NONL	3864	53	HONL	3605
			54	NONL	3527	54	NONL	3295	54	HONL	3692
						55	NONL	3894	55	NONL	3769
						56	NONL	3655	56	NONL	3524
						57	NONL	3124	57	NONL	3608
									58	NONL	3632
									59	NONL	3786
									60	NONL	3366
									61	NONL	2515

Table C17. Continued.

Population 1			Population 2			Population 3			Population 4		
Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}
									62	NONL	3779
									63	NONL	3352
									64	NONL	3369
									65	NONL	4089
									66	NONL	3359
									67	NONL	3850
									68	NONL	3716
									69	NONL	3581
									70	NONL	3739
									71	NONL	3722
									72	NONL	3662
									73	NONL	3937
									74	NONL	3685
									75	NONL	3615
									76	NONL	3763
									77	NONL	3302
									78	NONL	3766
SEM		202			173			176			173
LSD 0.05		576			491			500			489
LSD 0.01		771			656			667			650
92M61	Check	3874	92M61	Check	4077	92M61	Check	4161	92M61	Check	4047
92Y80	Check	3864	92Y80	Check	3400	92Y80	Check	4020	92Y80	Check	3143
93M11	Check	3757	93M11	Check	3530	93M11	Check	4012	93M11	Check	3760
93M42	Check	4060	93M42	Check	3830	93M42	Check	4003	93M42	Check	3936
92Y80‡	Check	3855	93M11‡	Check	3750	93Y11‡	Check	3830	93Y20‡	Check	3671
92Y30	Check	3696	93Y11	Check	3592	93Y11	Check	3619	93M61	Check	3110

Table C18. Mean performance of high-oleate/low-linolenate, high-oleate/normal-linolenate, and normal-oleate/normal-linolenate lines from the four populations grown at Napoleon, OH in 2009.

Population 1			Population 2			Population 3			Population 4		
Entry	Class†	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}
7	HOLL	4395	7	HOLL	3625	7	HOLL	4069	7	HOLL	3968
8	HOLL	3090	8	HOLL	4398	8	HOLL	4166	8	HOLL	2976
9	HOLL	3779	9	HOLL	3547	9	HOLL	4008	9	HOLL	3961
10	HOLL	3060	10	HOLL	4159	10	HOLL	3796	10	HOLL	4018
11	HOLL	2959	11	HOLL	3077	11	HOLL	3870	11	HOLL	4398
12	HOLL	3262	12	HOLL	4412	12	HOLL	4173	12	HOLL	4402
13	HOLL	3295	13	HOLL	3840	13	HOLL	3611	13	HOLL	3803
14	HOLL	3621	14	HOLL	3759	14	HOLL	3820	14	HOLL	3635
15	HOLL	3833	15	HOLL	3914	15	HOLL	4116	15	HOLL	4459
16	HOLL	4038	16	HOLL	3874	16	HOLL	3827	16	HOLL	4482
17	HOLL	3517	17	HOLL	3850	17	HOLL	4163	17	HOLL	3719
18	HOLL	3443	18	HOLL	3433	18	HOLL	3968	18	HOLL	3547
19	HOLL	3759	19	HOLL	4264	19	HOLL	4533	19	HOLL	3927
20	HOLL	3716	20	HOLL	3985	20	HOLL	4170	20	HOLL	3988
21	HONL	3591	21	HOLL	3534	21	HOLL	3847	21	HOLL	4465
22	HONL	3551	22	HOLL	4065	22	HOLL	4328	22	HOLL	4183
23	HONL	4001	23	HONL	3800	23	HOLL	3228	23	HOLL	3884
24	HONL	3510	24	HONL	3941	24	HONL	4351	24	HOLL	4311
25	HONL	4005	25	HONL	4011	25	HONL	3285	25	HOLL	3803
26	HONL	4106	26	HONL	4106	26	HONL	4045	26	HOLL	3699
27	HONL	3753	27	HONL	3490	27	HONL	4301	27	HOLL	3954
28	HONL	3571	28	HONL	3608	28	HONL	3927	28	HOLL	3837
29	HONL	3319	29	HONL	3800	29	HONL	4395	29	HOLL	3991
30	HONL	3416	30	HONL	3389	30	HONL	4334	30	HOLL	3904
31	HONL	3679	31	HONL	4314	31	HONL	3978	31	HONL	4280
32	HONL	3477	32	HONL	3887	32	HONL	3843	32	HONL	4092

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate, normal-linolenate lines.

‡ = Seed source is different from all other entries

Table C18. Continued.

Population 1			Population 2			Population 3			Population 4		
Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}
33	HONL	3006	33	HONL	4217	33	HONL	4220	33	HONL	3732
34	HONL	4005	34	HONL	3978	34	HONL	3500	34	HONL	4223
35	NONL	4127	35	HONL	4227	35	HONL	3901	35	HONL	3880
36	NONL	3729	36	HONL	3820	36	HONL	4008	36	HONL	3675
37	NONL	4022	37	HONL	4206	37	HONL	4065	37	HONL	4391
38	NONL	3665	38	HONL	4116	38	HONL	4338	38	HONL	4432
39	NONL	3665	39	NONL	3961	39	HONL	4102	39	HONL	3766
40	NONL	3662	40	NONL	4274	40	HONL	4015	40	HONL	4634
41	NONL	4133	41	NONL	4270	41	NONL	3692	41	HONL	3927
42	NONL	3991	42	NONL	4321	42	NONL	4607	42	HONL	3675
43	NONL	3635	43	NONL	3974	43	NONL	4082	43	HONL	4116
44	NONL	3705	44	NONL	3850	44	NONL	4233	44	HONL	4011
45	NONL	4011	45	NONL	4136	45	NONL	4267	45	HONL	3941
46	NONL	3823	46	NONL	4163	46	NONL	3769	46	HONL	3937
47	NONL	3934	47	NONL	4405	47	NONL	4223	47	HONL	3827
48	NONL	4075	48	NONL	4180	48	NONL	4223	48	HONL	4025
			49	NONL	3914	49	NONL	3974	49	HONL	4183
			50	NONL	4193	50	NONL	3887	50	HONL	3406
			51	NONL	4674	51	NONL	4260	51	HONL	3847
			52	NONL	3773	52	NONL	3951	52	HONL	4159
			53	NONL	4028	53	NONL	4432	53	HONL	4021
			54	NONL	3937	54	NONL	3655	54	HONL	4274
						55	NONL	4136	55	NONL	4640
						56	NONL	4418	56	NONL	4243
						57	NONL	4741	57	NONL	4496
									58	NONL	3958
									59	NONL	4714
									60	NONL	3531
									61	NONL	3746

Table C18. Continued.

Population 1			Population 2			Population 3			Population 4		
Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}	Entry	Class	Yield kg ha^{-1}
									62	NONL	4687
									63	NONL	4640
									64	NONL	4055
									65	NONL	4280
									66	NONL	4247
									67	NONL	4593
									68	NONL	4331
									69	NONL	4294
									70	NONL	4264
									71	NONL	4176
									72	NONL	4348
									73	NONL	4233
									74	NONL	4442
									75	NONL	3843
									76	NONL	3769
									77	NONL	3858
									78	NONL	3948
SEM		346			291			273			231
LSD 0.05		990			829			776			654
LSD 0.01		1324			1107			1035			869
92M61	Check	4223	92M61	Check	4552	92M61	Check	4079	92M61	Check	4451
92Y80	Check	3652	92Y80	Check	4228	92Y80	Check	4222	92Y80	Check	3938
93M11	Check	4193	93M11	Check	4343	93M11	Check	4404	93M11	Check	4336
93M42	Check	3988	93M42	Check	3909	93M42	Check	4331	93M42	Check	4061
92Y80‡	Check	4308	93M11‡	Check	4470	93Y11‡	Check	4242	93Y20‡	Check	4588
92Y30	Check	3867	93Y11	Check	4431	93Y11	Check	4470	93M61	Check	4150

APPENDIX D

DATA FOR ALTERNATIVE METHODS OF MEASURING PROTEIN AND OIL CONCENTRATIONS

Table D1. Protein and oil concentrations of 10 random lines from each of the three classes grown at the Atlantic environment in 2009.

Population	Line	Class†	Protein			Oil		
			Kjeldahl	NIR‡	Difference	Solvent Extraction	NIR	Difference
			g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}
Pop2	7	HOLL	348	354	6	181	179	2
Pop2	13	HOLL	352	356	4	171	169	2
Pop2	15	HOLL	363	369	6	169	171	2
Pop3	8	HOLL	361	360	1	184	174	10
Pop3	11	HOLL	362	360	2	186	181	5
Pop3	14	HOLL	360	362	2	189	185	4
Pop4	9	HOLL	340	344	4	185	179	6
Pop4	14	HOLL	356	359	3	174	177	3
Pop4	16	HOLL	368	370	2	178	174	4
Pop4	26	HOLL	351	365	14	180	177	3
		Mean	356	360	4	180	177	4
Pop2	23	HONL	340	365	25	174	176	2
Pop2	27	HONL	356	357	1	176	176	0
Pop2	31	HONL	345	353	8	179	173	6
Pop3	29	HONL	365	375	10	177	178	1
Pop3	33	HONL	352	360	8	190	186	4
Pop3	35	HONL	345	361	16	179	172	7
Pop3	40	HONL	350	361	11	174	172	2
Pop4	34	HONL	350	361	11	178	177	1
Pop4	48	HONL	362	370	8	179	177	2
Pop4	49	HONL	350	361	11	181	180	1
		Mean	352	362	11	179	177	3
Pop2	43	NONL	353	352	1	188	180	8
Pop2	50	NONL	345	347	2	186	178	8
Pop3	42	NONL	345	347	2	190	192	2
Pop3	44	NONL	357	360	3	186	180	6
Pop3	47	NONL	342	345	3	183	177	6
Pop3	49	NONL	349	347	2	192	188	4
Pop3	51	NONL	343	352	9	189	184	5
Pop3	55	NONL	352	353	1	193	186	7
Pop4	61	NONL	343	344	1	188	184	4
Pop4	73	NONL	348	344	4	188	184	4
		Mean	348	349	3	188	183	5

† HOLL = High-oleate, low-linolenate lines, HONL = high-oleate, normal-linolenate lines, NONL = normal-oleate/normal-linolenate lines.

‡NIR = Infratec 1221 near-infrared whole grain analyzer

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